MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

VOL. XLIV. FEBRUARY 8, 1884. No. 4.

E. J. STONE, M.A., F.R.S., President, in the Chair.

Thomas Allsop, Oakdene, Bexley, Kent;
Wentworth Bennett, Cadbury, Castle Cary, Somerset;
William Coleman, The Shrubbery, Buckland, Dover;
Joseph Davis, 6 Kennington Park Road, S.E.;
Thomas Read, B.A., 10 Barnpark Terrace, Teignmouth; and
Frederick William Watkin, B.A., St. Paul's School, E.C.;

were balloted for and duly elected Fellows of the Society.

REPORT OF THE COUNCIL TO THE SIXTY-FOURTH ANNUAL GENERAL MEETING OF THE SOCIETY.

The following table shows the progress and present state of the Society:—

	Compounders	Annual Subscribers	Non-resident	Mathematical Society	Total Fellows	Associates	Patron	Grand Total
December 31, 1882 ...	230	361	2	5	598	46	1	645
Since elected	+2	+28	...	...	...	+4	...	...
Deceased	−6	−8	...	−2	...	−1	...	...
Resigned	...	−9	...	...	...	...	...	...
Expelled	...	−1	...	...	...	...	...	...
December 31, 1883 ...	226	371	2	3	602	49	1	652

Mr. Barrow's Account as Treasurer of the Royal

RECEIPTS.

	£	s.	d.	£	s.	d.
Balances at Bankers, Jan. 1, 1883:						
Credited in pass book	514	4	9			
Amounts not credited	16	0	6			
On deposit account at Bankers'	500	0	0			
				1030	5	3
Balance in hand of Assistant Secretary on account of Turnor Fund, Jan. 1, 1883	6	15	4			
,, in hand of Hon. Secretary on account of payments for Computation of Ephemerides, Jan. 1, 1883	12	10	0			
				19	5	4
*Dividend on £7,500 Consols	108	15	0			
* ,, £5,700 New 3 per cent. Stock ...	83	3	9			
* ,, £7,500 Consols	110	3	2			
* ,, £5,700 New 3 per cent. Stock ...	83	14	5			
Dividends on £500 Metropolitan Stock	7	7	0			
Interest on money on deposit at Bankers' ...	10	6	7			
				403	9	11
Received on account of Subscriptions:						
Arrears	195	6	0			
261 Annual Contributions	548	2	0			
28 Admission Fees	58	16	0			
26 First Contributions	43	1	0			
				845	5	0
2 Composition Fees				42	0	0
Sales of Publications:						
At Williams & Norgate's, 1882	48	7	3			
At Society's Rooms, 1883	33	11	7			
				81	18	10
				£2,422	4	4

* Half-years' dividends.

Astronomical Society, from Dec. 31, 1882, to Dec. 31, 1883.

EXPENDITURE.	£	s.	d.	£	s.	d.
Assistant Secretary: Salary	225	0	0			
„ „ for assistance in editing Society's publications...	50	0	0			
				275	0	0
Income Tax and House Duty				11	3	1
Fire Insurance				7	16	6
Printing: Spottiswoode & Co.	345	1	0			
Engraving and Lithography	33	8	2			
Computation of Ephemerides in *Monthly Notices*, 1882	12	10	0			
Computation of Ephemerides in *Monthly Notices*, 1883	50	0	0			
				440	19	2
Turnor and Horrox Funds: Purchase of Books for Library	19	15	2			
Binding Books in Library	40	11	7			
Petty Library expenses	3	7	1			
				63	13	10
Decorations and Repairs to Society's Apartments: Burdett & Sons	491	8	9			
Mr. Ruddle: for preparing Specifications, &c. ...	15	15	0			
Examining and cleaning Heating Apparatus: Haden & Son...	5	6	0			
Carpet, Floorcloth, &c., and cleaning Carpets: Tyler & Co.	17	9	2			
				529	18	11
House Expenses	31	13	7			
Wages	22	4	0			
Postage, &c.	55	0	11			
Carriage of parcels, &c.	1	11	10			
Stationery and office expenses	9	0	8			
Expenses of meetings	20	0	0			
Coals and gas	65	10	11			
Sundry repairs, &c.	13	17	9			
Sundries	6	16	8			
				225	16	4
Lee fund				55	0	0
Mrs. Jackson-Gwilt's annuity				8	19	0
Purchase of £500 Metropolitan Board of Works stock at 98, including commission				490	12	6
Bankers' commissions on cheques		3	0			
Powers of attorney for receipt of dividends ...		11	6			
Cheque book		8	4			
				1	2	10
Balance at bankers' Dec. 31, 1883	291	9	6			
„ in hand of Assistant Secretary on account of Turnor and Horrox Funds...	7	0	2			
„ in hand of Assistant Secretary on Petty Cash account...	10	18	11			
				309	8	7
Due to Assistant Secretary on Petty Cash account, Jan. 1, 1883				2	13	7
				£2,422	4	4

Audited and found correct, Jan. 5, 1884.

G. L. Tupman,
Robt. J. Lecky.
C. G. Talmage.

Assets and present property of the Society, January 1, 1884:—

	£	s.	d.	£	s.	d.
Balance at Bankers', Dec. 31, 1883	291	9	6			
„ in hand of Assistant Secretary on account of Turnor and Horrox Funds... ...	7	0	2			
on Petty Cash account	10	18	11			
				309	8	7
Due on account of subscriptions:						
1 Contribution of 6 years' standing ...	12	12	0			
1 „ 4 „ ...	8	8	0			
14 „ 3 „ ...	88	4	0			
27 „ 2 „ ...	113	8	0			
61 „ 1 „ ...	128	2	0			
3 Admission fees and first contributions ...	9	9	0			
				360	3	0
Due from Messrs. Williams & Norgate (for sales of Publications during 1883)				28	10	3

£7,500 Consols, including the Lee Fund, the Turnor Fund, and the Horrox Memorial Fund.

£5,700 New 3 per cent. Stock, including Mrs. Jackson-Gwilt's gift (£300).

£500 Metropolitan Board of Works Stock.

Astronomical and other MSS.; Books, Prints, Instruments, and Furniture.

Unsold Publications of the Society.

Two Gold Medals.

Report of the Auditors.

We, being the duly appointed Auditors, beg to lay before this General Meeting of the Royal Astronomical Society the following Report:—

We have examined the Treasurer's account, and an account of the assets and property of the Society, and have found and certified the same to be correct.

The receipts and expenditure for the past year are as stated in the Treasurer's account. The cash in hand on December 31, 1883, including the balance at the bankers', amounted to 309*l.* 8*s.* 7*d.*

The sum of 500*l.* has been invested in Metropolitan Board of Works Stock: the amount of funded property standing in the name of the Society is therefore 13,700*l.*, being an increase of 500*l.* from the previous year. The sum of 500*l.* on deposit at the bankers' has been withdrawn to pay for the decorations and repairs to the Society's rooms.

The books, instruments, and other effects have been examined and found in a satisfactory condition, so far as their safe keeping is concerned.

We have laid on the table a list of the names of those Fellows who are in arrear for sums due at the last Annual General Meeting, with the amount due against each Fellow's name.

G. L. Tupman.
C. G. Talmage.
Robt. J. Lecky.

Stock in hand of volumes of the *Memoirs*:—

Vol.	At Society's Rooms	At Williams & Norgate's	Vol.	At Society's Rooms	At Williams & Norgate's
I. Part 1	6	...	XXVIII.	388	...
I. Part 2	41	...	XXIX.	415	...
II. Part 1	52	...	XXX.	165	...
II. Part 2	19	...	XXXI.	147	...
III. Part 1	67	1	XXXII.	162	...
III. Part 2	86	1	XXXIII.	168	1
IV. Part 1	81	3	XXXIV.	168	6
IV. Part 2	92	3	XXXV.	111	6
V.	108	4	XXXVI.	197	12
VI.	127	3	XXXVII. Part 1	345	7
VII.	151	3	XXXVII. Part 2	294	6
VIII.	129	3	XXXVIII.	284	2
IX.	128	3	XXXIX. Part 1	257	4
X.	148	...	XXXIX. Part 2	262	4
XI.	155	...	XL.	288	2
XII.	160	...	XLI.	440	2
XIII.	165	1	XLII.	250	5
XIV.	373	3	XLIII.	264	1
XV.	141	...	XLIV.	250	1
XVI.	168	1	XLV.	301	3
XVII.	149	2	XLVI.	328	5
XVIII.	149	...	XLVII. Part 1	2	...
XIX.	155	...	XLVII. Part 2	20	...
XX.	156	...	XLVII. Part 3	1	...
XXI. Part 1	314	...	XLVII. Part 4	20	...
XXI. Part 2	99	...	XLVII. Part 5	21	...
XXI. 1 & 2 (together)	63	1	XLVII. Part 6	21	...
XXII.	157	...	XLVII.	301	9
XXIII.	152	1	Index to *Memoirs*	649	1
XXIV.	159	1			
XXV.	171	...			
XXVI.	174	1			
XXVII.	428	...			

Stock in hand of volumes of the *Monthly Notices*:—

Vol.	At Society's Rooms	At Williams & Norgate's	Vol.	At Society's Rooms	At Williams & Norgate's
I.	72	...	XXIV.	23	...
II.	74	...	XXV.	7	...
III.	...	...	XXVI.	9	...
IV.	...	...	XXVII.	3	...
V.	...	...	XXVIII.	72	1
VI.	39	...	XXIX.	54	...
VII.	2	...	XXX.	67	2
VIII.	139	2	XXXI.	98	...
IX.	23	3	XXXII.	119	5
X.	174	1	XXXIII.	103	2
XI.	186	1	XXXIV.	83	2
XII.	11	2	XXXV.	66	1
XIII.	150	3	XXXVI.	33	1
XIV.	109	3	XXXVII.	40	3
XV.	128	2	XXXVIII.	103	2
XVI.	108	3	XXXIX.	103	1
XVII.	136	1	XL.	116	3
XVIII.	166	...	XLI.	123	3
XIX.	57	...	XLII.	129	4
XX.	34	...	XLIII.	130	12
XXI.	17	...	Index to *Monthly Notices*	584	1
XXII.	32	...			
XXIII.	28	...			

In addition to the above volumes of the *Monthly Notices*, the Society has a considerable stock of separate numbers of nearly all the volumes. With the exception, however, of Vols. XXXVI. to XLIII. no complete volumes can be formed from the separate numbers in stock.

Instruments belonging to the Society.

No. 1. The *Harrison* clock.
„ 2. The *Owen* portable circles, by Jones.
„ 3. The *Beaufoy* circle.
„ 4. The *Beaufoy* transit instrument.
„ 5. The *Herschel* 7-foot telescope.
„ 6. The *Greig* universal instrument, by Reichenbach and Ertel. The transit telescope, by Ultzschneider and Fraunhofer, of Munich.

No. 7. The *Smeaton* equatoreal.
„ 8. The *Cavendish* apparatus.
„ 9. The 7-foot Gregorian telescope (late Mr. Shearman's).
„ 10. The variation transit instrument (late Mr. Shearman's).
„ 11. The universal quadrat, by Abraham Sharp.
„ 12. The *Fuller* theodolite.
„ 13. The standard scale, by Troughton and Simms.
„ 14. The *Beaufoy* clock, No. 1.
„ 15. The *Beaufoy* clock, No. 2.
„ 16. The *Wollaston* telescope.
„ 17. The *Lee* circle.
„ 18. The *Sharpe* reflecting circle.
„ 19. The *Brisbane* circle.
„ 20. The *Baker* universal equatoreal.
„ 21. The *Reade* transit.
„ 22. The *Matthew* equatoreal, by Cooke.
„ 23. The *Matthew* transit instrument.
„ 24. The *South* transit instrument.
„ 25. A sextant, by Bird (formerly belonging to Captain Cook).
„ 26. A globe showing the precession of the equinoxes.
The *Sheepshanks* collection :—
„ 27. (1) 30-inch transit instrument, by Simms, with level and two iron stands.
„ 28. (2) 6-inch transit theodolite, with circles divided on silver; reading microscopes, both for altitude and azimuth; cross and siding levels; magnetic needle; plumbline; portable clamping foot and tripod stand.
„ 29. (3) $4\frac{6}{10}$-inch achromatic telescope, about 5 feet 6 inches focal length; finder; rack motion; double-image micrometer; two other micrometers; object-glass micrometer; one terrestrial and ten astronomical eyepieces, applied by means of two adapters; equatoreal stand, and clock movement.
„ 30. (4) $3\frac{1}{4}$-inch achromatic telescope, with equatoreal stand; double-image micrometer; one terrestrial and three astronomical eyepieces.
„ 31. (5) $2\frac{3}{4}$-inch achromatic telescope, with stand; one terrestrial and three astronomical eyepieces.
„ 33. (7) 2-foot navy telescope.
„ 34. (8) Transit instrument of 45 inches focal length; with iron stand, and also Ys for fixing to stone piers; two axis levels.
„ 35. (9) Repeating theodolite, by Ertel, with folding tripod stand.
„ 36. (10) 8-inch pillar sextant, by Troughton, divided on platinum, with counterpoise stand and artificial horizon.

No. 37. (11) Portable zenith telescope and stand, $2\frac{3}{4}$-inch aperture and 26 inches focal length; 10-inch horizontal circle and 8-inch vertical circle, read to 10″ by two verniers to each circ'e.

„ 38. (12) 18-inch Borda repeating circle, by Troughton, $2\frac{1}{8}$-inch aperture and 24 inches focal length; the circles divided on silver, the horizontal circle being read by four verniers, and the vertical circle by three verniers, each to 10″.

„ 39. (13) 8-inch vertical repeating circle, with diagonal telescope, by Troughton and Simms; circle divided on silver, reading to 10″; a 5-inch circle at eye-end reading to single minutes; horizontal circle 9 inches diameter in brass, reading to single minutes.

„ 40. (14) A set of surveying instruments, consisting of a 12-inch theodolite for horizontal angles only, reading to 10″; two sets of adjusting plates; tripod stand with enclosed telescope; heavy stand for theodolite; Y piece of level; two large and three small ground-glass bubbles divided; level collimator, object-glass $1\frac{5}{8}$-inch diameter and 16 inches focal length; micrometer eyepiece, comb, and wires; mercury bottle and trough.

„ 41. (15) Level collimator with object-glass $1\frac{7}{8}$-inch diameter and 16 inches focal length; stand, rider-level, and fittings.

„ 42. (16) 10-inch reflecting circle, by Troughton, reading by three verniers to 20″; counterpoise stand; artificial horizon with mercury; two tripod stands.

„ 43. (17) Hassler's reflecting circle, by Troughton, with counterpoise stand.

„ 44. (18) 6-inch reflecting and repeating circle, by Troughton and Simms, contained in three boxes, two of which form stands. Circle divided on silver, reading to single minutes; two inside arcs divided to single degrees, 150 degrees on each side; artificial horizon and mercury.

„ 45. (19) 5-inch reflecting and repeating circle, by Lenoir, of Paris.

„ 46. (20) Reflecting circle by Jecker, of Paris, 11 inches in diameter, with one vernier reading to 15″.

„ 47. (21) Box sextant; reflecting plane and level.

„ 48. (22) Prismatic compass, by Troughton and Simms.

„ 49. (23) Mountain barometer.

„ 50. (24) Prismatic compass, by Thomas Jones, mounted with a cylindrical lens.

51. (25) Ordinary $4\frac{1}{2}$-inch compass with needle.

„ 52. (26) Dipping needle, by Robinson.

„ 53. (27) Compass needle, mounted for variation.

„ 54. (28) Magnetic intensity needle, by Meyerstein, of

Göttingen; a strongly fitted brass box with heavy magnet; filar suspension.

No. 55. (29) Box of magnetic apparatus.

„ 56. (30) Hassler's reflecting circle, by Troughton; a 10½-inch reflecting and repeating circle, with stand and counterpoise, divided on platinum with two movable and two fixed indices; four verniers reading to 10″.

„ 57. (31) Box sextant and glass plane artificial horizon, by Troughton and Simms.

„ 58. (32) Plane 2⅜-inch speculum, artificial horizon, and stand.

„ 59. (33) 2½-inch circular level horizon, by Dollond.

„ 60. (34) Artificial horizon, roof, and trough; the trough 8¼ by 4½ inches: tripod stand.

„ 61. (35) Set of drawing instruments, consisting of 6-inch circular protractor and common protractor, T-square: one beam compass.

„ 62. (36) A pentagraph.

„ 63. (37) A noddy.

„ 64. (38) A small Galilean telescope with object-glass of rock crystal.

„ 65. (39) Five levels.

„ 66. (40) 18-inch celestial globe.

„ 67. (41) Varley stand for telescope.

„ 69. (43) Telescope, with the object-glass of rock crystal.

„ 70. Portable equatoreal stand.

„ 71. Portable altazimuth tripod.

„ 72. Four polarimeters.

„ 74. Registering spectroscope, with one large prism.

„ 76. Two five-prism direct-vision spectroscopes.

„ 78. 9¼-inch silvered-glass reflector and stand, by Browning.

„ 79. Spectroscope.

„ 80. A small box, containing three square-headed Nicol's prisms; two Babinet's compensators; two double-image prisms; three Savarts; one positive eyepiece, with Nicol's prism; one dark wedge.

„ 81. A back-staff, or Davis' quadrant.

„ 82. A nocturnal or star dial.

„ 83. An early non-achromatic telescope, of about 3 feet focal length, in oak tube, by Samuel Scatliffe, London.

„ 84. A Hollis observing chair.

„ 85. Double image micrometer, by Troughton and Simms.

„ 86. 4½-inch Gregorian reflecting telescope, by Short, with altazimuth stand and 6-inch altitude and azimuth circles and two eyepieces.

87. 3¼-inch Gregorian reflecting telescope with wooden tripod stand.

No. 88. Pendulum with 5-foot brass suspension rod, working on knife edges, by Thomas Jones.

„ 89. A Rhabdological Abacus. A contrivance invented by Mr. H. Goodwyn, consisting of a box filled with compartments, in which are square rods covered with numbers, which can be arranged so as to facilitate the labour of multiplying high numbers.

„ 90. An Arabic celestial globe of bronze, not quite 6 inches in diameter.

„ 91. Astronomical time watchcase, by Professor Chevallier.

„ 92. 2-foot protractor, with two moveable arms, and vernier.

„ 93. Beam compass, in box.

„ 94. 2-foot navigation scale.

„ 95. Stand for testing measures of length.

„ 96. Artificial planet and star, for testing the measurement of a fixed distance at different position-angles.

„ 97. 12-cell Leclanché battery.

„ 98. 2 feet 6 inch navy telescope with object-glass $2\frac{1}{2}$ inches, by Cooke, with portable wooden tripod stand.

„ 99. 12-inch transit instrument, by Fayrer & Son, with level and portable stand.

„ 100. 9-inch transit instrument, with level and iron stand.

„ 101. Small equatoreal sight instrument, by G. Adams, London.

„ 102. Sun-dial, by Troughton.

„ 103. Sun-dial, by Casella.

„ 104. Sun-dial.

„ 105. Box sextant, by Troughton and Simms.

„ 106. Prismatic compass, by Schmalcalder, London.

„ 107. Compass, by C. Earle, Melbourne.

„ 108. Prismatic compass, by Negretti and Zambra.

„ 109. Dipleidoscope, by E. Dent.

„ 110. Abney level, by Elliott.

„ 111. Pocket spectroscope, by Browning.

„ 112. Small brass astrolabe.

„ 113. Double sextant, by Jones.

„ 114. Two models, illustrating the effects of circular motions.

„ 115. A cometarium.

„ 116. A pair of 18-inch globes.

„ 117 } Two old sun-dials, bequeathed by the late W. S.
„ 118 } Heineken, Esq.

The following instruments are lent, during the pleasure of the Council, to the undermentioned persons :—

No. 4. The *Beaufoy* transit instrument, to the Observatory, Kingston, Canada.
„ 23. The *Matthew* transit, to Captain W. Noble.
„ 74. Registering spectroscope, with prism, to Mr. R. J. Lecky.
„ 76. One five-prism direct-vision spectroscope, to Mr. Talmage.

From the *Sheepshanks* collection :—

No. 27. (1) 30-inch transit instrument and stand, to Mr. G. M. Whipple.
„ 29. (3) Clock and equatoreal mounting, to Mr. R. Bryant.
„ 29. (3) Three micrometers, to Mr. E. Ristori.
„ 30. (4) $3\frac{1}{4}$-inch equatoreal and stand, to Mr. H. Sadler.
„ 31. (5) $2\frac{3}{4}$-inch telescope and stand, to Mr. E. Ristori.
„ 34. (8) Transit instrument, to Prof. C. Pritchard.
„ 69. (43) Telescope, with rock-crystal object-glass, to Dr. W. Huggins.

The Gold Medal.

The Council have awarded the Society's Gold Medal to Mr. A. A. Common for his photographs of Celestial Bodies. The President will lay before the Society the grounds upon which this award has been founded.

Publications of the Society.

Vol. XLVII. of the *Memoirs* has been published during the past year. It contains the following papers :—

On the Moon's Photographic Diameter, and on the Applicability of Celestial Photography to Accurate Measurement. By Prof. C. Pritchard.

Observations of the Transit of *Venus*, 1874, December 8–9, made in Victoria, New South Wales, South Australia, India, and the Cape of Good Hope. By R. L. J. Ellery, H. C. Russell, J. Tebbutt, C. Todd, Captain Bigg Wither, E. J. Stone, &c.

Measures of Sir John Herschel's Cape Stars, together with a List of New Double Stars. By H. C. Russell.

Double-star Observations made in 1879 and 1880 with the $18\frac{1}{2}$-inch Refractor of the Dearborn Observatory, Chicago. By S. W. Burnham.

On the Solar Motion in Space. By W. E. Plummer.

Photometric Determination of the Relative Brightness of the Brighter Stars North of the Equator. By Prof. C. Pritchard.

Obituary.

The Council regret that they have to record the loss by death of the following Fellows and Associates during the past year:—

Fellows:—Francis Abbott.
George Bishop.
C. J. Corbett.
W. A. Cross.
J. H. Dallmeyer.
Joseph Drew.
Rev. N. S. Godfrey.
F. C. Green.
Gen. Sir H. Harness.
Julius Page.
Gen. Sir E. Sabine.
Rev. A. Smith.
Prof. H. J. S. Smith.
William Spottiswoode.
Thomas Warner.
T. R. White.

Associates:—Wilhelm Klinkerfues.
J. F. J. Schmidt.
Yvon Villarceau.

Charles Joseph Corbett was born on May 29, 1823, at Mareham-le-Fen, in Lincolnshire, and was the third son of Mr. Joseph Corbett of that place.

By profession, Mr. Corbett was an architect, and it was not till about fifteen years ago that he turned his attention seriously to astronomy. From that time, until advancing years and infirmity of eyesight compelled him to give up work, he occupied himself chiefly in the investigation of solar phenomena, and made a number of observations of Sun-spots, which, however, he was never able to complete. His work was carried on at his own observatory, at Imber Court, Thames Ditton, his residence in Surrey. He died on March 24, 1882, and was buried at Thames Ditton. He was elected a Fellow of the Society on December 10, 1869.

Colonel William Assheton Cross, of Red Scar, near Preston, was educated at Rugby, and Trinity College, Cambridge. He devoted himself from an early age to scientific pursuits, and had constructed a well-appointed Observatory at his residence even in his college days. Here he had mounted equatorially a celebrated 5-foot refractor by Dollond, once the property of the Rev. W. R. Dawes, with which many of that well-known observer's early observations had been made. Later in life Colonel Cross became

the friend and disciple of the late Mr. Lassell, and under his guidance succeeded admirably in grinding and polishing very excellent specula, one of which, a Newtonian of 15 in. diameter, he mounted equatorially, with all the best appliances, in a second Observatory with hemispherical dome. The figure of this speculum was wonderfully perfect, and elicited the warmest approval from Mr. Lassell. By a rude stroke of fate, one which denotes the rapid strides that have been made in the size of astronomical instruments in the course of one generation, Dawes's refractor mentioned above was degraded to become the finder of the new reflector. An excellent eye and remarkable mechanical skill were conspicuous in Col. Cross, and had not his time and powers been occupied by other matters, he would have earned for himself a high place among amateur astronomers. He died suddenly at the age of 64. He was elected a Fellow of the Society on April 14, 1848.

Joseph Drew, son of the late Joseph Drew, of the Dockyard Service, R.N., was born May 21, 1814, at Deptford. He was founder, proprietor, and editor from 1850 to 1862, of the *Southern Times*, and author of "In the Beginning," "The Mystery of Creation," "Our Home in the Stars," "The Rival Queens," "The Life of the Duke of Wellington," and other essays. He delivered gratuitously nearly 200 lectures, scientific and historical, at various institutions in the south-west of England between 1867 and 1876.

The degree of LL.D. was conferred on him by Richmond University, U.S.A., in 1874. He was a Fellow of the Geological Society, and a member of several other scientific and literary societies. He was elected a Fellow of this Society on January 13, 1871.

Nathaniel Stedman Godfrey was the only child of Nathaniel Godfrey, Esq., of London. After leaving St. Catherine's College, Cambridge, he became curate at Swansea, and subsequently at Biddenham, near Bedford. He then became incumbent of Wortley, near Leeds, and after taking temporary duty at Portsea and Southsea he became the first vicar of St. Bartholomew's Church, Southsea, and occupied this position until his death, which took place, after a long and painful illness, on October 26, 1883, in the 66th year of his age. He married Caroline Ann, the second daughter of Joseph Goodhart, Esq., of Hackney. He was successful as a composer of sacred music, and published several doctrinal works, some of them of a controversial character, and all of the Evangelical type.

Mr. Godfrey possessed a fine Newtonian reflector with silver-on-glass mirror, 9-ft. focus, by Calver, which he had mounted in an Observatory of his own contrivance. In some letters to the *English Mechanic* in 1879–80 he defended reflecting telescopes, pointing out the cause of frequent complaint, and showing

how he had obtained accurate adjustment in his own case. In one of these letters he mentioned that in the course of forty-five years he had possessed about fifteen achromatic telescopes from $2\frac{1}{4}$ in. up to 7 in.; the object of the letter was to explain how the definition of a fine mirror could be made equal to that of a fine achromatic. He was elected a Fellow of the Society on December 9, 1864.

Frederic Charles Green was born at Bolton, and educated at Bolton and Birkenhead schools. He took the greatest interest in seamanship and nautical matters, both practical and theoretical; and all the time that he could spare from his business of bleaching cotton goods, he devoted to the working of a small sail-boat of his own, and to studying such questions as the law of storms, methods of observing at sea, &c., and he occasionally wrote to the nautical papers on these subjects. To put his knowledge to a practical test, he passed the Board of Trade Examination. It was his great endeavour to assist mates and others engaged in practical seamanship in obtaining the requisite knowledge of the theoretical part of the subject. He was not thirty years of age when he died, of consumption, at the Isle of Man, where he had gone for the sake of his health. He was elected a Fellow of the Society on January 12, 1883.

Sir Henry Drury Harness was a son of John Harness, M.D., Commissioner of the Transport Board, and was born in the year 1804. He was educated at the Royal Military Academy, Woolwich. It was a time of reaction in military affairs, and he felt the effects of this in having to suffer a delay of two years in obtaining his commission. He employed this interval in making an excursion to Mexico, where the silver mines were then attracting the attention of English adventurers. He was appointed second lieutenant in the Royal Engineers, and his first service was at Bermuda, under General Blanshard. In 1832 he was made first lieutenant. He returned to England in 1834, and was appointed an Instructor of Fortification at the Royal Military Academy, Woolwich. At this time he laid the foundations of those papers which were afterwards expanded to form a text-book of Fortification for that school. In 1840 he went to the Engineer School at Chatham, as Instructor in Surveying. At Woolwich and at Chatham he attracted his pupils, both to himself and to the subject of study, by his simple winning manner, and by his patient disposition. He became second captain in 1843. For a short time in 1844 he was Professor of Fortification at the Royal Military Academy, Woolwich. In 1845 he accepted the office of Inspector of Welsh Roads, which was established at that time, in consequence of the change from the system of maintaining them by turnpikes to that of county rates. At this time, the manner of dealing with the new railways became a subject of difficulty to the Board of Trade, and a separate Commission was appointed, of

which Captain Harness was one of the two Secretaries. It was subsequently merged in the Board of Trade, and he became sole Secretary.

During this time the railway system was developing with great rapidity, and he was therefore brought into contact with all the principal railway engineers of the day. Independently of these duties, he was at the time also acting as arbitrator between the Post Office and the railway companies, a responsible and difficult service, the subject of the arbitration being the remuneration to be paid to the railway companies for the conveyance of the mails. He was next called upon to undertake the duty of reforming the Royal Mint, on the basis of the report of a Royal Commission, which had been appointed to inquire into its constitution and management. The Master of the Mint at that time (1850) was a political officer, whose responsibilities were limited to his Parliamentary duties. Captain Harness was appointed Deputy-Master, and became the responsible head of the department. The mechanical operations connected with the production of coin were then directed and controlled by a quasi-corporation of melters, assayers, and moneyers, who contracted with the Deputy-Master for the execution of the coinage at certain prices; and the task assigned to Captain Harness was to convert this corporation into a Government department. This he successfully accomplished, and he had been virtually appointed Master of the Mint, when, it being considered desirable that this office should be held by an eminent scientific man, his nomination was rescinded, and the appointment given to Sir John Herschel.

He worked loyally under his new chief till the reforms were completed, when he resigned. The Governorship of New Zealand was then offered to him, but he declined it. After this he went as a Commissioner of Public Works to Ireland, and there he remained two years. He returned to England in 1855, to take the position of head of the fortification branch in the office of the Inspector-General of Fortifications, and he held this post during the latter part of the Crimean war. He was then appointed to the command of the Royal Engineers at Malta; but he had not been there long when the mutiny in India broke out, and he was offered the command of the body of Royal Engineers which was to form part of the force under Lord Clyde, and this offer he at once accepted. He had been appointed first captain in 1847, brevet-major in 1854, lieutenant-colonel in 1855. He took part in the operations at Cawnpore against the Gwalior contingent, the siege and capture of Lucknow, and the subsequent engagements in Rohilkund and Oudh. He distinguished himself by personal bravery in the field; and for his services in India he was several times mentioned in despatches. He was also nominated a Companion of the Order of the Bath, and received the medal and clasps.

On his return from India he was appointed, in 1860, the head of what is now the School of Military Engineering at

Chatham; and under his direction the whole establishment was rearranged in a form more suited to modern military science. In 1866 the cattle plague was giving much anxiety and trouble to the Privy Council; a separate department was created for a time to undertake all that the new Orders in Council required, and General Harness was placed at the head of it, and thus found himself the virtual dictator of the cattle trade of the country. He became major-general in 1868, and in 1877 he was appointed a colonel-commandant, Royal Engineers, and promoted to the rank of lieutenant-general in the army, after which he was placed on the retired list as a general. He became a K.C.B. in 1873. The last duty he undertook was to be President of a Committee on Siege Operations.

He was entrusted by the Ordnance authorities with the editing of a Course of Mathematics for the Royal Military Academy, which was published in 1853, and was till lately used there as a text-book. The late Dr. Peter Barlow, who was his colleague at Woolwich, and with whom he kept up a close friendship afterwards, gave him great assistance in the preparation of this work. His life was one of constant work, but the mere record of his services gives no just idea of the influence he exerted upon those with whom he was brought in contact during his long career.

He married, in 1828, Caroline, daughter of Mr. Thomas Edmunds, of Cowbridge, Glamorganshire; and died on February 10, 1883, at Barton End, Headington, Oxford. He was elected a Fellow of this Society on December 15, 1839.

J. W. L. G.

Julius Page was the only son of Richard Page, Esq., and in early life was associated in business with his father, who was engaged in the Stock Exchange, and was a frequent writer in the *Times* on the currency, under the name of Daniel Hardcastle. In 1834 Julius Page entered the house of Messrs. Baring Brothers, and remained with them as a valued and much respected clerk until failing health compelled his retirement in 1869. He married in 1834, and had one child, a daughter, who survives him. He died at Greenwich on August 6, 1883, in the 83rd year of his age.

Mr. Page was a member of the old Mathematical Society, and became a Fellow of the Royal Astronomical Society when the former Society was merged in it in 1845. Mr. Page occupied himself for many years with conic sections, treated algebraically, but not by the methods of analytical geometry, and he always took great interest in the solution of problems connected with this subject. He was the last surviving member of the old Mathematical Society, who was a true and characteristic representative of its methods and objects as they were in its best days. In the *Monthly Notices* for 1878 (vol. xxxviii. pp. 145–147), in the obituary notice of Dr. Bowerbank, there was given an account by Mr. Page of the Society as he remembered it. He there states that

he became a member of it in 1823, when it met in Crispin Street, Spitalfields.

Mr. Page was a man of retiring disposition, only seeking enjoyment in his books, his conic sections, and his lathe. He had acquired a large fund of knowledge, which he was always ready to impart to those who sought for it. He was an acknowledged authority on Exchange and Foreign Bills, and wrote much in conjunction with his father on Peel's Bank Act, and also on the Corn Laws. One of the last subjects that he was interested in was paper currency, and his views were published, with those of others, in a volume by the late Lord Overstone.

Sir EDWARD SABINE was the son of Mr. Joseph Sabine of Lewin, and was born in Dublin, on October 14, 1788. The family to which he belonged, said to be of Italian origin, early settled in Normandy, and removed thence to this country. He received his early education at the Royal Military Colleges of Marlow and Woolwich, obtaining a commission as second lieutenant in the Royal Artillery when but fifteen years of age, on December 22, 1803, and receiving his captaincy in 1813. He served in the American War, 1813–1816, and was present in the campaign of 1814 on the Niagara frontier. He commanded the batteries at the siege of Fort Erie, and was favourably mentioned in despatches. On the conclusion of the war he was appointed, on the recommendation of the President and Council of the Royal Society, astronomer of the first expedition in search of the North-West Passage, commanded by Sir John Ross, in 1818. On the return of that expedition, he accompanied, in the same capacity, the second expedition, 1819–1820, commanded by Sir Edward Parry. As the result of his observations he made two communications to the Royal Society, which were published in the *Philosophical Transactions*, one relating to the irregularities observed in the direction of the compass needle consequent upon the attraction of the iron of the ships, and the other to the variations of the magnetic needle and the intensity of the magnetic force during the voyage. In the latter he pointed out the importance of founding a widely-extended series of observations of magnetic disturbances.

In 1821 and 1822 he conducted a series of pendulum experiments for determining the figure of the earth at several stations at or near the Equator, on the coasts of Africa and America in H.M.S. *Pheasant*, and in 1823 he extended the series to Greenland, Spitzbergen, and Norway, in H.M.S. *Griper*. In these voyages he also paid attention to various other questions, such as deep-sea temperature, ocean currents, the measurement of heights barometrically, the influence of the Gulf Stream on the coasts of Europe, &c. His papers on these and other subjects were published in the *Philosophical Transactions*, the *Edinburgh Journal of Science*, and the *Quarterly Journal of Science*.

In 1825 he and Sir John Herschel were appointed the

British members of a joint commission between the French and English Governments to determine the difference of longitude between the Observatories of Paris and Greenwich by means of rocket signals. In 1827 he was employed in determining by direct observation the difference in the length of the seconds pendulum at Paris and Greenwich; and at the same time he made a series of experiments in order to determine the ratio of the magnetic forces acting on a needle horizontally suspended at these two places. The results of the experiments appeared in the *Philosophical Transactions*, when he also published other papers relating to pendulum observations.

From this time onwards his energies were mainly devoted to researches on terrestrial magnetism, which is the subject with which his name will always be chiefly connected. Numerous memoirs of his, representing an immense amount of work, were published in the *Philosophical Transactions*, the British Association *Reports*, Quetelet's *Correspondance Mathématique*, &c.; in fact, during the forty years from 1830 to 1870 he laboured earnestly and persistently to extend our knowledge of the magnetic condition of the globe, and the present state of this science is mainly due to his untiring efforts. In the British Association *Reports* from 1835 to 1838 he published memoirs relating to the magnetic intensity in the British Isles and over the Earth's surface. By 1838 he had so completely demonstrated the importance of magnetic observations being carried out in all parts of the world, that Capt. James Ross was sent with the *Erebus* and *Terror* to make a magnetical survey of the Antarctic regions, and Sabine accompanied the expedition. He had induced the Admiralty to promote the establishment of observatories in the Colonies, and on the voyage out, magnetical and meteorological observatories were founded at St. Helena, the Cape, and Hobarton (Van Diemen's Land). These observatories were placed under his superintendence, and at this time a general magnetic survey was commenced by him under the direction of the Admiralty. The observatories remained under his control for many years, and the magnetic survey of the globe continued to occupy his chief attention so long as he was capable of work. The results were communicated to the Royal Society in a series of elaborate papers. His last paper appeared in 1872, when he gave a magnetical survey of the North Polar regions. The infirmities of age were then stealing upon him, and he would scarcely have been able to complete it without the assistance of Sir Frederick Evans, the present Hydrographer of the Admiralty. As one of the results of the observations made at the Colonial Observatories, Sabine was led to notice the connection between the number of spots on the Sun and magnetic disturbances. He contributed altogether nearly forty papers to the *Philosophical Transactions*.

In 1826 he married Elizabeth Juliana, daughter of Mr. W. Leeves; she was the companion of his labours, and assisted him in all his work. She died in 1879. He had a great admiration

of Humboldt, and edited an English translation of his *Cosmos* made by Mrs. Sabine. In 1830, in consequence of the disturbed state of Ireland, where his company of artillery was then stationed, he was required to join it; and he also served there, partly with his regiment and partly on the general staff of the army in Ireland, from 1833 to 1837.

He was elected a Fellow of the Royal Society on April 16, 1818, so that for the long period of sixty-five years he was a Fellow of that Society. His first paper, on the birds of Greenland, was communicated to the Linnean Society in the same year (1818); his contributions to science, therefore, cover no less than fifty-four years. He was Secretary of the Royal Society in 1827, in 1846 Foreign Secretary, in 1850 Vice-President and Treasurer. In 1861 he succeeded Sir Benjamin Brodie as President, and held the office until 1871. He was General Secretary of the British Association from 1839 to 1858, and was President at the meeting in Belfast in 1852. He was elected a Fellow of this Society on November 8, 1839.

He was awarded the Copley medal of the Royal Society in 1821, and a Royal medal in 1849; he also received the Lalande medal of the French Academy. He became lieutenant-colonel in 1851, and major-general in 1859. He was made a K.C.B. in 1869. He was an honorary member or associate of almost every foreign academy and scientific society of note. He died at his residence at London on June 26, 1883, in his ninety-fifth year, and was buried at Tewin beside his wife on June 30. For some time before his death his faculties had failed him. He leaves no family.

J. W. L. G.

Henry John Stephen Smith was born on November 2, 1826, and was the fourth child of his parents. His father, John Smith, was a barrister-at-law, and graduated at Trinity College, Dublin, and afterwards at Brasenose College, Oxford, in order to shorten the residence at the Inns of Court that was requisite before he could be called to the bar. At the Temple he was the law pupil of Henry John Stephen, serjeant-at-law, the editor of "Blackstone's Commentaries," and the pupil gave the master's name to the younger of his two sons.

When Henry Smith was just two years old his father died. There were four children, two sons and two daughters, of whom the eldest, a girl, was but nine years of age; and to their education the widow thenceforth devoted herself. Chiefly in order to give her children the better opportunity of education which England afforded, Mrs. Smith left Ireland, and after spending some time in the Isle of Man, at Harborne near Birmingham, and at Leamington, she moved in 1831 to Ryde, in the Isle of Wight, where she remained for nearly ten years. Mrs. Smith was a most accomplished lady, and an intense delight in learning was one of the ruling impulses of her life. She taught her children herself, and until Henry was over eleven he remained

under her exclusive care and teaching. He was able to read when he was three years of age, and while still between four and five he began to display the desire for learning and the facility for acquiring knowledge that distinguished him ever afterwards. When he was between eleven and twelve his mother, who had been reading Greek plays, Herodotus and Thucydides with the boys, began to feel herself unable to cope with the further difficulties of Latin and Greek composition, and Mr. R. Wheler Bush became their tutor for some months. In a letter to the *Times* of February 12, 1883, Mr. Bush has given an account of the work of his pupil, from which the following is an extract:—

"In the years 1838–39 Henry Smith, then a boy of eleven years of age, read with me for about nine months at Ryde, in the Isle of Wight. He had been previously taught by his widowed mother—a remarkably clever and highly educated woman. After reading with Henry Smith I had a large experience of boys during a head-mastership of more than thirty-three years, but I have often remarked that the brilliant talents of Henry Smith prevented me from ever being really astonished at the abilities of any subsequent pupil. His power of memory, quickness of perception, indefatigable diligence, and intuitive grasp of whatever he studied were very remarkable at that early age. What he got through during those few months, and the way in which he got through it, have never ceased to surprise me. From a record which I have before me I see that during that short time he read all Thucydides, Sophocles, and Sallust, twelve books of Tacitus, the greater part of Horace, Juvenal, Persius, and several plays of Æschylus and Euripides. I see also that he got up six books of Euclid, and algebra to simple equations; that he read a considerable quantity of Hebrew; and that, among other things, he learnt all the Odes of Horace by heart. I could scarcely understand at the time how he contrived at his early age to translate so well and so accurately the most difficult speeches of Thucydides, without note or comment to guide him. He was a deeply interesting boy, singularly modest, lovable, and affectionate."

Mr. Bush was succeeded by two other tutors of less ability, and Mrs. Smith found that adequate teaching for Henry could not be obtained from resident tutors. She accordingly removed to Oxford in the autumn of 1840, when he became the daily pupil of the Rev. H. Highton. In the summer of 1841 Mr. Highton was appointed to a mastership at Rugby. He was accompanied by his pupil, who, being only fifteen, was disqualified by age from entering the sixth form, although possessed of sufficient knowledge. He was placed in the upper fifth and in "the twenty" until the Midsummer holidays of 1842, when having been allowed the privilege of bidding Dr. Arnold goodbye, as a boy who would commence the next term in the sixth form, he returned home, where the news of Dr. Arnold's sudden

death followed him the next day. He went back to Rugby, and soon became the head boy under Dr. Tait.

On the death of his elder brother from consumption, in September 1843 he was removed from Rugby, and remained with his family at Nice through the winter, almost without classical books and without even a Greek lexicon. He spent the summer of 1844 in Switzerland, and at the beginning of October it was thought that he should return to Rugby for a few weeks' preparation before going to Oxford to try for the Balliol Scholarship in November. He was successful in obtaining the scholarship, and joined his family at Rome before Christmas. The winter was one of great enjoyment to him, and he made rapid progress in knowledge and cultivation while studying diligently the antiquities of the city.

He accompanied his family in June 1845 to Frascati, where in August he was attacked by malaria, the effects of which invalided him for nearly two years. The winter was spent at Naples, the malady slowly wearing itself out. In May 1846 he was taken to Wiesbaden, where the waters rapidly restored him to fair health. It was not, however, thought expedient that he should resume his interrupted course at Oxford until Easter 1847. The intervening winter was spent at Paris, and like the preceding one was a time when he made rapid intellectual progress. He remembered with especial pleasure the lectures of Arago and Milne Edwards. After the Easter term of 1847 he was never to the time of his death absent from Oxford for a single term. In the summer of 1847 he once more visited Wiesbaden, returning with his family to England in October. Until his mother's death, in 1857, his vacations were all passed with his family, the Christmas and Easter vacations chiefly in London, and the summer in Germany, Switzerland, or Austria.

He won the Ireland Scholarship in the Lent term 1848, and obtained a first class both in the classical and mathematical schools in the Lent term 1849. He gained the Senior Mathematical Scholarship in 1851. He was elected a Fellow of Balliol in 1850, and resided in college till 1857, when, after his mother's death, his only surviving sister, Miss Eleanor E. Smith, came to Oxford, and from that time onwards they lived together. He was elected Savilian Professor of Geometry in 1861 in succession to Prof. Baden Powell, and in 1874 he was appointed Keeper of the University Museum. He then removed to the residence attached to the Museum, and lived there with his sister till his death.

After taking his degree he wavered between classics and mathematics, but not for long; the latter soon attracted him, and with a power that steadily increased from year to year. His first two papers, which were geometrical, were published in 1852 in the *Proceedings of the Ashmolean Society* and the *Cambridge and Dublin Mathematical Journal*. His next paper entitled "De Compositione numerorum primorum formæ $4\lambda+1$ ex

duobus quadratis," was published in *Crelle's Journal* for 1855. This was his first contribution to the subject to which he was to mainly devote his life, and with which his name will ever be associated. For the ten years from 1854 to 1864 he devoted himself to the Theory of Numbers, the most extensive and the most difficult of all the branches of pure mathematics, and made himself master of everything that had been published upon it. The results of this enormous amount of research are contained in his Report on the Theory of Numbers, which appeared in the British Association volumes from 1859 to 1865. Although incomplete, this magnificent Report occupies nearly 250 pages, and forms an enduring monument of the power and genius of its author. It is quite unique of its kind, and presents a comprehensive view of the actual state of the most intricate department of mathematics, and only those who have had occasion to make use of it can appreciate the wonderful grasp exhibited by the author of *all* the processes and methods and literature of the subject. It is a model of brief, clear, and precise exposition, and is remarkable for the same perfection of form, condensed mode of statement of processes, and what may be termed "mathematical good taste" that distinguished all his work.

Not only does the Report contain a complete account of the wonderful series of discoveries of Gauss and his successors, but there is also much original matter, though with characteristic modesty it is but rarely that it is distinguished in any way from theorems that are merely quoted. But the amount of original work that he accomplished was far greater than he could find room for in the Report, and the chief results of his own discoveries were communicated to the Royal Society in two elaborate memoirs on systems of linear indeterminate equations and congruences, and upon the orders and genera of ternary quadratic forms, which were printed in the *Philosophical Transactions* for 1861 and 1867. The two great divisions into which the Theory of Numbers may be divided are the Theory of Congruences and the Theory of Forms, and these papers contain contributions of the highest generality and importance to both branches of the subject. The solution of the problem of the representation of numbers by binary quadratic forms is one of the great achievements of Gauss, and the fundamental principles upon which the treatment of such questions must rest were given by him in the *Disquisitiones Arithmeticæ*. Gauss there added some results relating to ternary quadratic forms, but the extension from two to three indeterminates was the work of Eisenstein, who, in his memoir "Neue Theoreme der höheren Arithmetik," defined the ordinal and generic characters of ternary quadratic forms of an uneven determinant; and, in the case of definite forms, assigned the weight of any order or genus. But he did not consider forms of an even determinant, nor give any demonstrations of his work, and these omissions Prof. Smith supplied in his great memoir on the subject, which affords a complete classification of

ternary quadratic forms. Prof. Smith, however, did not confine himself to the case of three indeterminates, but succeeded in establishing the principles on which the extension to the general case of n indeterminates depend, and obtained the general formulæ; thus effecting the greatest advance made in the subject since the publication of Gauss's memorable work that so entirely changed the aspect of the whole Theory of Numbers. A brief account of Prof. Smith's methods and results appeared in the *Proceedings of the Royal Society* (vol. xiii., 1864, pp. 199–203, and vol. xvi., 1868, pp. 197–208) in two notices, "On the Order and Genera of Quadratic Forms containing more than Three Indeterminates." In the second of these notices, after giving the general formulæ, Prof. Smith remarks that, though the demonstrations are simple in principle, they require attention to a great number of details with respect to which it is very easy to fall into error, and he adds "so soon as they can be put into a convenient form they shall be submitted to the Royal Society;" but unfortunately he was closely occupied with other researches during all that remained of his life, and when death removed him so suddenly last year they still lay unpublished in his note-books.

In this second notice he also remarks at the conclusion that the theorems which have been given by Jacobi, Eisenstein, and in such great profusion by Liouville, relating to the representation of numbers by four squares and other simple quadratic forms, are deducible by a uniform method from the principles indicated in the paper, and he proceeds, "So also are the theorems relating to the representation of numbers by six and eight squares, which are implicitly contained in the developments given by Jacobi in the 'Fundamenta Nova.' As the series of theorems relating to the representation of numbers by sums of squares ceases, for the reason assigned by Eisenstein, when the number of squares surpasses eight, it is of some importance to complete it. The only cases which have not been fully considered are those of five and seven squares. The principal theorems relating to the case of five squares have indeed been given by Eisenstein (*Crelle's Journal*, vol. xxxv. p. 368); but he has considered only those numbers which are not divisible by any square. We shall here complete his enunciation of those theorems, and shall add the corresponding theorems for the case of seven squares." The class of theorems in question (viz. the number of representations of a number as a sum of squares) was shown by Eisenstein to be limited to eight squares. The solutions in the cases of two, four, and six squares may be obtained by means of Elliptic Functions, *i.e.* by purely algebraic methods, but the cases in which the number of squares is uneven involve the special processes peculiar to the Theory of Numbers. Eisenstein gave the solution in the case of three squares, and he also left a statement of the solution he had obtained in the case of five squares. His results, however, were

published without demonstration, and only apply to numbers having a particular form. Fourteen years later, in ignorance of Prof. Smith's work, the demonstration and completion of Eisenstein's theorems for five squares were set by the French Academy as the subject of their "Grand Prix des Sciences Mathématiques." When Prof. Smith saw the announcement of the prize subject, in February 1882, his time was engrossed with work relating to Elliptic Functions, and besides having a great dislike to become a competitor, especially under the circumstances, he was very reluctant to leave, even for a short time, the work he had in hand. At the request, however, of a member of the Commission by whom the prize had been proposed, he undertook to write out the demonstration of his general theorems so far as was required to prove the results in the special case of five squares. The dissertation was sent in by the day appointed (June 1, 1882), and only a month after his death, in March 1883, the prize of 3,000 francs was awarded to him, another prize being also awarded to M. Minkowski. No episode could bring out in a more striking light the extent of Prof. Smith's researches, or the distance he had advanced beyond his contemporaries than that a question of which he had given the solution in 1867 as a corollary from general formulæ which governed the whole class of investigations to which it belonged should have been regarded by the French Academy as one whose solution was of such difficulty and importance as to be worthy of their great prize. It affords, too, a singular illustration of the little attention that works destined to become classical attracted in the lifetime of their author. In the Royal Society's *Proceedings* Prof. Smith's statement of his results relating to five squares and seven squares occupy but a single page, but his dissertation (which has been printed by the French Academy), although it only relates to the case of five squares, occupies 72 pages. Many of the propositions contained in it are general, but the demonstrations are not supplied for the case of seven squares.

Prof. Smith was also the author of important papers in which he succeeded in extending to complex quadratic forms many of Gauss's investigations relating to real quadratic forms.

He was led by his researches on the Theory of Numbers to the Theory of Elliptic Functions; and on this subject he has published since 1864 results scarcely inferior in importance to his achievements in the former theory. His third subject was Modern Geometry, in which he was without a rival in this country, and of which he showed the same perfect mastery. Pure mathematics is divisible into two great branches, the Theory of Numbers, or "Arithmetic," *i.e.* the theory of discrete magnitude, and Algebra, the theory of continuous magnitude, the aims and methods of the two subjects being quite distinct. A characteristic of Prof. Smith's work, no less than of Gauss's, is the "arithmetical" mode of treatment that runs through the whole of it, no matter what the subject; and his

great command over the processes of this science is everywhere conspicuous. Special reference ought to be made to one paper of his in the *Atti* of the Accademia dei Lincei for 1877, in which he established a very remarkable analytical relation connecting the modular equation of order n and the theory of binary quadratic forms belonging to the positive determinant n. In this paper the modular curve is represented analytically by a curve in such a manner as to present an actual geometrical image of the complete systems of the reduced quadratic forms belonging to the determinant, and a geometrical interpretation is given to the ideas of *class*, *equivalence*, and *reduced form*. His papers on Elliptic Functions and the higher singularities of curves were published chiefly in the *Proceedings of the Mathematical Society*. At the time of his death he was engaged on a memoir on the "Theta and Omega Functions," which he left nearly complete, 150 quarto pages of it being in type; the latter portion, however, had not been revised in proof by him. This was the memoir which he was forced to lay aside for a time, in order to write out from his notes of 1866–67 the dissertation on the problem of five squares for the French Academy.

In 1868 he was awarded the Steiner prize of the Berlin Academy for a geometrical memoir "Sur quelques Problèmes cubiques et biquadratiques." He was asked to contribute to the memorial volume to Chelini, published at Milan in 1881 by Cremona and Beltrami, and he wrote a paper in Latin on continued fractions. He also wrote the introduction to the collected edition of Clifford's mathematical papers (1882).

Prof. Smith's collected mathematical works will be issued by the Oxford University Press in two volumes quarto. His lectures on Geometry and Theory of Numbers will also be published as text-books, the former being reproduced from the notes of pupils who attended them.

In the early years of his work he had published his researches but sparingly, and it was only as the mass of results accumulated that the necessity for publication pressed itself upon him. The excellence and completeness that distinguished all that Gauss ever published was a characteristic of Prof. Smith's work, and, as in Gauss's case, it was the result of extreme thought and care and elaboration. He was a great admirer of Gauss, and the following words of his relating to Gauss are quoted here in their entirety, as they perfectly describe, and in his own language, the objects which Prof. Smith himself so successfully kept in view in all that he wrote:—

"If we except the great name of Newton (and the exception is one which Gauss himself would have been delighted to make), it is probable that no mathematician of any age or country has ever surpassed Gauss in the combination of an abundant fertility of invention with an absolute rigorousness in demonstration, which the ancient Greeks themselves might have envied. It may be admitted, without any disparagement to the eminence of such

great mathematicians as Euler and Cauchy, that they were so overwhelmed with the exuberant wealth of their own creations, and so fascinated by the interest attaching to the results at which they arrived, that they did not greatly care to expend their time in arranging their ideas in a strictly logical order, or even in establishing by irrefragable proof propositions which they instinctively felt, and could almost see, to be true. With Gauss the case was otherwise.

'It may seem paradoxical, but it is probably nevertheless true, that it is precisely the effort after a logical perfection of form which has rendered the writings of Gauss open to the charge of obscurity and unnecessary difficulty. The fact is that there is neither obscurity nor difficulty in his writings as long as we read them in the submissive spirit in which an intelligent schoolboy is made to read his Euclid. Every assertion that is made is fully proved, and the assertions succeed one another in a perfectly just, analogical order; there is nothing so far of which we can complain. But when we have finished the perusal we soon begin to feel that our work is but begun, that we are still standing on the threshold of the temple, and that there is a secret which lies behind the veil, and is as yet concealed from us. . . . No vestige appears of the process by which the result itself was obtained, perhaps not even a trace of the considerations which suggested the successive steps of the demonstration. Gauss says, more than once, that for brevity he only gives the synthesis, and suppresses the analysis of his propositions. *Parca sed matura* were the words with which he delighted to describe the character which he endeavoured to impress upon his mathematical writings. If, on the other hand, we turn to a memoir of Euler's, there is a sort of free and luxuriant gracefulness about the whole performance which tells of the quiet pleasure which Euler must have taken in each step of his work; but we are conscious, nevertheless, that we are at an immense distance from the severe grandeur of design which is characteristic of all Gauss's greater efforts. The preceding criticism, if just, ought not to appear wholly trivial, for though it is quite true that in any mathematical work the substance is immeasurably more important than the form, yet it cannot be doubted that many mathematical memoirs of our own time suffer greatly (if we may dare to say so) from a certain slovenliness in the mode of presentation, and that (whatever may be the value of their contents) they are stamped with a character of slightness and perishableness which contrasts strongly with the adamantine solidity and clear, hard modelling which (we may be sure) will keep the writings of Gauss from being forgotten long after the chief results and methods contained in them have been incorporated in treatises more easily read, and have come to form a part of the common patrimony of all working mathematicians. And we must never forget (what in an age so fertile of new mathematical conceptions as our own we are only too

apt to forget) that it is the business of mathematical science not only to discover new truths and new methods, but also to establish them, at whatever cost of time and labour, upon a basis of irrefragable reasoning.

"The μαθηματικὸς πιθανολογῶν has no more right to be listened to now than he had in the days of Aristotle; but it must be owned that since the invention of the 'royal roads' of analysis, defective modes of reasoning and of proof have had a chance of obtaining currency which they never had before. It is not the greatest, but it is perhaps not the least, of Gauss's claim to the admiration of mathematicians, that while fully penetrated with a sense of the vastness of the science, he exacted the utmost rigorousness in every part of it, never passed over a difficulty as if it did not exist, and never accepted a theorem as true beyond the limits within which it could actually be demonstrated."

These words describe not only Prof. Smith's views but the quality of his own work. His one care was that it should be imperishable; and the words "adamantine solidity" express better than any others could do the character of what he has left. He spared no time or pains that his work should be as complete in its details as in its main results, and that it should be as perfect in form as in substance. He wished that what he did should be done for all time, and that it should also receive from his own hand the form which it was to retain.

He was President of Section A of the British Association at Bradford in 1873 and of the Mathematical Society in 1874–76, and the presidential addresses which he delivered at Bradford and on vacating the latter office are masterpieces of graceful writing that bear record to his wonderfully extensive knowledge and rare combination of gifts. As an expounder of mathematics before an audience he was unsurpassed for clearness, and his singular charm of manner gave him a remarkable power of fixing the attention of those present. Perhaps his faultless method of exposition and peculiar grace of manner were never more apparent than at the Mathematical Society on December 12, 1882—the last occasion on which he was ever to lay before a society the results of his wonderful power of penetration into the innermost structure, as it were, of mathematical truth.

His contributions to general literature were not numerous; a memoir of his friend Prof. Conington and an essay on the Plurality of Worlds were the most important. The articles on Arithmetical Instruments and on Geometrical Instruments and Models which he wrote for the handbook published in connection with the Special Loan Exhibition of Scientific Apparatus at South Kensington in 1876, should also be noticed.

He was appointed a member of the Royal Commission on Scientific Instruction and the Advancement of Science in 1870 on the death of Prof. W. A. Miller; and he was also a member of the Oxford University Commission, appointed in 1877. On

both Commissions a great deal of very heavy work was performed by him; and knowing how short was to be the time for which he was to be spared, it is impossible not to regret the great amount of time and anxiety that were thus exacted from him. A considerable portion of the report of the former Commission, including the part which related to the Universities of Oxford and Cambridge, was drafted by him.

In 1877, on the reconstitution of the managing body of the Meteorological Office, as recommended by the Treasury Commission in 1876, Prof. Smith was requested to accept the chairmanship of the new council. This office, which involved weekly visits to London, in addition to council meetings, which usually took place once a fortnight, he still held at his death. During the five years and a half of his presidency, he never missed a meeting, and he always devoted at least two hours to the consideration of the business on the agenda paper. The Minutes were always revised by him in manuscript before they were printed. In 1879 he was requested by the Council to attend the International Meteorological Congress at Rome, where his wide and varied knowledge and great personal influence made themselves felt throughout the whole meeting and contributed greatly to its success.

He was elected a Fellow of the Royal Society in 1861. On April 12 of the same year he was elected a Fellow of this Society. He was an LL.D. of Cambridge and Dublin.

It is difficult to give an idea of the position Prof. Smith held in Oxford and in society generally, so brilliant were his attainments, and so great and so varied his personal and social gifts. In an article on him in the *Times* of February 10, 1883, it was truly said: "It is probable that of the thousands of Englishmen who knew Henry Smith, scarcely one in a hundred ever thought of him as a mathematician at all . . . He was a classical scholar of wide knowledge and exquisite taste, and there were few who talked to him on English, French, German, or Italian literature who were not struck by his extensive knowledge, his capacious memory, and his sound critical judgment." The writer might have added that, even of the few who did think of him as a mathematician, there were fewer still who had any suspicion of the place he held in mathematical science, or of his intense devotion to the subject. The following extracts from the *Spectator* of February 17 will help to convey some impression of his personal character: "Many even of those who are aware that a man in the fulness of his powers is just dead, whose brilliant intellectual attainments have probably not been surpassed by any other of their English contemporaries may, nevertheless, be surprised at regret so widely felt and so loudly expressed over the loss of one who wrote no great books, patented no great invention, amassed no fortune, made no famous speeches, and led no conspicuous movement, political or social. Measured by the popular measure of publicity and fame, Prof. Henry Smith would

hardly seem to most of us to have been one of the great men of the time. Yet it would be difficult, among the world's celebrities, to find one who in gifts and nature was his superior . . . His mental attainments were of the highest order. A finished classical scholar, a mathematician, in some respects of European distinction, a considerable metaphysician, a trained master of most branches of knowledge, literary, economic, and scientific, an adequate linguist, and a man of sound judgment, perfect temper, and wise aptitude for affairs, he combined with his other special excellences a delicate gaiety of spirit, a brilliant conversational power, which made him one of the most accomplished and attractive ornaments of any educated company in which he moved. . . . Vanity or self-seeking, every form of mental intemperance and extravagance, seemed to have no place in anything that he ever said or did . . . Among the many friends, acquaintances, admirers, whose thoughts have in the last few days been saddened or sobered by the unexpected death of a brilliant man of genius, there are none who will not readily accord to Prof. Henry Smith the tribute of unaffected respect for what, without extravagance, may be termed his extraordinary powers of mind, his gentle and Lælian wisdom, and the sweetness of character which never made an enemy, lost a friend, or sought a personal advantage for itself." Referring to his influence at Oxford the article proceeds: "For nearly thirty years no more attractive, brilliant, or genial figure was to be found in the perturbed society of the University. Some happy combination of judgment and temper made him acceptable even to those with whose opinions he had nothing in common. He had the great art of never pressing a victory home, and of bearing defeat with pleasant equanimity. His business powers, his modesty, his wisdom, and his entire freedom from egotism and dogmatic presumption, a delicate gaiety that never flagged, wit that sparkled without wounding, and which rose incessantly to real brilliancy, made him not merely an effective personage in the Oxford world, but universally acceptable in any society, whatever the shade of its opinions . . . As by degrees his attainments were recognised, both in England and abroad, his influence at Oxford naturally deepened, but neither within nor without the University did he grasp at opportunities of notoriety. Such power and authority as he possessed he held without an effort, without solicitation, apparently without any personal satisfaction in them. In offices of friendship he was constant; in such public or civic duties as came in his way, assiduous; no good or benevolent work ever needed a helping hand but his was at its service, without ostentation and without any expectation of personal advantage." The notice of him in the *Athenæum* closed with the words: "No one, probably, has ever had a larger circle of private friends to lament his loss. He had all the gifts which win and preserve attachment; not only sincerity, constancy, depth of feeling and liveliness of sympathy, but a sweetness and nobility of nature to which no words can render adequate testimony."

In commenting on his nomination as one of the Oxford University Commissioners, Mr. Grant Duff said in the House of Commons: "The Savilian Professor of Geometry is not merely in the first rank of European mathematicians, but he would be a man of very extraordinary attainments even if you could abstract from him the whole of his mathematical attainments. He was the most distinguished scholar of his day at Oxford . . . But Prof. Smith's extraordinary attainments are the least of his recommendations for the office of Commissioner. His chief recommendations for that office are the solidity of his judgment, his great experience of Oxford business, his services on the Science Commission, and his conciliatory character, which has made him perhaps the only man in Oxford who is without an enemy, sharp as are the contentions of that very divided seat of learning." Those who knew Prof. Smith will feel that even these quotations fail to convey any adequate idea of the extent and brilliance of his attainments and powers.

The amount of time and thought that he devoted to the Royal Commissions, Boards of Delegates at Oxford, the Meteorological Office, and Committees and Councils of Societies, was very great, and it seems almost incredible that one who lived so active and busy a life, passed in the midst of men and affairs, should have been the author of mental achievements in the most abstract and complicated of the sciences, which will rank as scarcely second to any in the century. His influence and position he owed to his personal qualities alone, and many of those who thought they knew him best had the least idea how incessantly he was occupied with mathematical researches. The cold severity of his mathematical writings forms a curious contrast to the brilliant gaiety of his manner, and future generations, who will know him only from his writings, will find it hard to believe what they will find recorded of their author. In the character of his work he closely resembles Gauss, but no two lives could be more different.

An accident to his leg confined him to his sofa during part of 1882, but he seemed to have nearly recovered from its effects when he was seized with the illness which so soon carried him off. He was a regular attendant at the Council Meetings of this Society, and, at the time of his death, was a Vice-President. At the meeting of Council on February 2, 1883, the writer of this notice received from him at Burlington House a letter—almost the last which he ever wrote—in which he said: "I cannot be at the R. A. S. to-morrow. It is no fault of mine . . . I shall see you on the ninth, I hope." The ninth was the date of the Anniversary Meeting, but at seven o'clock on that morning he died, and the first words spoken by the President, on taking the chair, were to announce to the Fellows the loss they had just sustained. He was buried at Oxford on February 13: conspicuous among those who stood by his grave was Mr. Spottiswoode, himself so soon to be removed.

J. W. L. G.

William Spottiswoode was born in London on January 11, 1825. He belonged to an ancient Scottish family, many members of which have risen to distinction in Scotland and in America. He was first sent to a school at Laleham, under Mr. Buckland, brother of Dean Buckland. Thence he was removed to Eton, where his stay was short. He was transferred from Eton to Harrow, then under Dr. Wordsworth, his house tutor being Mr. Harris. On entrance he was placed on the "upper shell," a high form in those days for a new comer. At school he was a very studious, quiet, and thoughtful boy, not much given to athletic games. He remained at Harrow three years, and in 1842 obtained a Lyon scholarship. In the same year he entered Balliol College, Oxford, the present Bishop of Exeter (Dr. Temple) being his mathematical tutor. Subsequently, in 1845, the last year of his residence as an undergraduate, he read with the Rev. Bartholomew Price, now Sedleian Professor of Natural Philosophy at Oxford. He took a first class in mathematics, and afterwards obtained the Junior (1846) and Senior (1847) University Mathematical Scholarships. After his degree he resided at Oxford for a short time, and gave a course of lectures at Balliol College on Geometry of Three Dimensions. After leaving Oxford, in 1846, he immediately took an active part in the working management of the business of the Queen's Printers, which was relinquished to him by his father, Andrew Spottiswoode. He possessed remarkable gifts as an organiser, and the business developed largely under his hands. In 1861 he married the eldest daughter of the late William Urquhart Arbuthnot, a distinguished member of the Indian Council.

Spottiswoode's first published work was a small quarto volume of 136 pages, containing five tracts upon different subjects in pure mathematics. This volume appeared in 1847, under the title *Meditationes Analyticæ*. Four years later he published a much more notable pamphlet, entitled *Elementary Theorems relating to Determinants*. A second edition, rewritten and much enlarged, was published in Vol. li. of *Crelle's Journal*. This was the earliest elementary treatise on a useful mathematical notation which, with the algorithm and processes connected with it, has since risen to great importance, and has influenced every branch of Mathematics, and many of its applications. It contains a good account of what had at that time been effected on this subject, and is the best known of Spottiswoode's mathematical writings.

He was the author of numerous papers, chiefly relating to geometry treated analytically, and to symbolic methods, which were printed in the publications of the Royal Society, the *Proceedings of the London Mathematical Society*, the *Philosophical Magazine*, the *Quarterly Journal of Mathematics*, *Crelle's Journal*, the *Comptes Rendus*, the *Proceedings of the Royal Institution*, &c. He was the author of but one paper published by this Society: it appeared in Vol. xxix. (1861) of the *Memoirs*, under the title "On a Method for Determining Longitude by means of Observations on the Moon's Greatest Altitude."

He contributed to the *Journal of the Royal Asiatic Society* two papers, the one relating to the supposed discovery of the principle of the differential calculus by an Indian astronomer, and the other to the Súrya Siddhánta and the Hindoo method of calculating eclipses.

In 1856 he made a journey through Eastern Russia, and of this he published an account in his book *A Tarantasse Journey through Eastern Russia in the Autumn of* 1856 (London, 1857).

Since 1870 he divided his attention between mathematics and physics; and the papers on electrical discharges through rarefied gases, published by him alone, and also conjointly with Mr. J. F. Moulton, in the *Philosophical Transactions*, are well known.

The prevailing character of his mathematical work may be said to be *symmetry*: and he has been called, like Serret, "un artiste en formules." He was most attracted by what may be called the morphology of mathematics, as, for example, results deduced from the *form* of the expressions. The following words of his own are worth reproducing here, as they not only point out the influence of such matters on the progress of science, but also indicate the kind of work that interested him the most. "There are a few certain relations so elementary in their conception, yet so universal in their application, that they seem capable of forming the basis of extensive theories; such, for example, in geometry is that of anharmonic ratio. Such, again, in algebra are those of homogeneity and of symmetry, which prove to be not merely improvements in form but actually new powers for progress in the hands of the mathematician. The calculus of homogeneous forms has marked a new era in the history of algebra; the theory of equations has been transfigured in its light; mechanics, both ordinary and molecular, have been elucidated by it; and the remote applications of the integral calculus have felt its ever-extending influence. Under these, as it were, new fundamental conceptions whole theories may be coordinated; and of these, again, perhaps some coordination may one day be contemplated. As another instance of this generalisation of principles, and of this dual aspect of the principles so generalised within almost the present generation, it has been discovered, or at all events been duly realised, that symbols of operation combine according to definite laws, comprising as a particular case those of ordinary number. This fertile idea has, year by year, been receiving fuller developments, till it has at last assumed the form of a complete calculus."

His Presidential Address to the London Mathematical Society, which related to the modern algebras that have so distinguished the progress of mathematics in our day, attracted considerable attention among those interested in symbolic processes and symbolic logic. His British Association Address at Dublin, in 1878, related mainly to the philosophy of mathematical theories which depend essentially upon the modern ideas which have grown up so recently in connection with the theory of space.

He showed great ability as an organiser wherever he had to do with business in any form; and he had in the highest degree the faculty of warmly attaching to himself friends and acquaintances. He was a many-sided man, and it was the combination in him of various gifts and powers, and not the prominence of any one in particular, that won for him so distinguished a position among the men of his time. As a business man he possessed a wonderful capacity for mastering the most complicated detail. He was a man of the world, with a very wide circle of friends, chief among whom were the most earnest and most devoted labourers in different departments of knowledge. His house at Grosvenor Place was the centre of scientific society in London, and his garden parties at his country estate near Sevenoaks were brilliant gatherings of men eminent in various walks of life.

He was Treasurer of the British Association from 1861 to 1874, of the Royal Institution from 1865 to 1873, and of the Royal Society from 1871 to 1878. In 1871 he succeeded Dr. Bence Jones as Honorary Secretary of the Royal Institution. He was President of the Mathematical and Physical Section of the British Association in 1865, of the British Association itself in 1878, and of the London Mathematical Society in the two years 1870–72. He was elected President of the Royal Society in 1878, in succession to Sir Joseph Hooker, and still held this office at the time of his death. He was an LL.D. of Cambridge, Dublin, and Edinburgh, and a D.C.L. of Oxford. He was elected a Fellow of this Society on April 7, 1852. He died on June 27, 1883, of Roman, or typhoid, fever, which he had caught during a visit to Italy. From the first his illness had caused serious alarm; and the more so as his strength had been materially affected by a severe tricycle accident which he met with in the previous year, and as his indefatigable attention to duties of various kinds had greatly overtaxed his constitution. Since Sir Joseph Banks, no President of the Royal Society has died in office. He was buried in Westminster Abbey on July 5, in a grave near that of his ancestor, Archbishop Spottiswood.

In his Presidential Address to the Royal Society on November 30, 1883, Prof. Huxley, referred to his predecessor as a chief, "of whom all those who had the highest interests of this Society at heart hoped that he would continue for many a year to discharge the responsible and laborious duties of his office with that broad intelligence, that faithful diligence, that inexhaustible patience and courtesy, which were so characteristic of the man," and he proceeded as follows:

"Every one of the Fellows of the Society in whose hearing I speak, knows that these are no words of a conventional eulogy, as of a customary epitaph. But it is only those who worked with our late President in the Council, or as officers of the Society, who are in a position fully to appreciate his singular capacity for the transaction of business with clear judgment and rapid decision, and yet with the most conscientious consideration of the

views of those with whom he was associated. And I may add that it is only those who enjoyed Mr. Spottiswoode's intimate friendship, as it was my privilege to do for some quarter of a century, who can know how much was lost when there vanished from among us that rare personality, so commingled of delicate sensitiveness with marvellous self-control, of rigid principle with genial tolerance, of energetic practical activity with untiring benevolence, that it always seemed to me the embodiment of that exquisite ideal of a true gentleman which Geoffrey Chaucer drew five hundred years ago. . . . It is not for me to pass judgment upon Mr. Spottiswoode's scientific labours; but I have the best authority for saying that, having occupied himself with many branches of mathematics, more especially with the higher algebra, including the theory of determinants, with the general calculus of symbols, and with the application of analysis to geometry and mechanics, he did excellent and durable work in all; and that in virtue of his sound and wide culture, his deep penetration, and the singular elegance with which he habitually treated all his subjects, he occupied a place in the front rank of English mathematicians.

"The interment in Westminster Abbey of one who, though compelled to devote a large share of his time to business, was a born man of science, and had won himself so high a place among mathematicians, was doubtless grateful to us as men of science, . . . yet as men, I think it is good to regard those solemn and pathetic obsequies as the tribute which even our busy, careless, cynical, modern world spontaneously pays to such worth and wisdom, to such large humanity and unspotted purity, as were manifested in the 'very perfect gentle knight' who so well represented the chivalry of science."

Perhaps no words could more happily express the estimation in which Mr. Spottiswoode was held by his friends.

J. W. L. G.

Thomas Warner was born at Leyton, Essex, on June 16, 1822, and died suddenly at Brighton on January 3, 1883. He was a younger son of the late Edward Warner, of Walthamstow, Essex, and was educated at Totteridge Park School and Trinity College, Cambridge, where he graduated in 1846. He married, in 1847, Elizabeth, youngest daughter of Richard Peckover Harris, Esq., of Walthamstow. In 1876 he published a work entitled "How to keep the Clock right by Observations of the Fixed Stars with a small fixed Telescope. Together with Tables of Stars arranged to show, by the use of a little arithmetic, the mean solar time of their apparent transits to the end of the century." This was an improved edition, the first edition having appeared in 1869. He also took considerable interest in mathematical tables and arithmetical calculations.

Mr. Warner was resident for more than thirty years at Brighton, and held the position of a justice of the peace on the

local bench of magistrates for many years. He will be remembered in Brighton for his active and philanthropic life and his many and munificent charities. He was a liberal supporter of the Sussex County Hospital, and had attended a meeting of its Board on the morning of the day he died. He was elected a Fellow of the Society on January 11, 1867.

Thomas Reynolds White died at his residence, Killingworth House, Northumberland, on May 29, 1883, after a long illness, caused by paralysis, aged 70 years. He was descended on his mother's side from an ancient Northumbrian family (the Killingworths of Killingworth), and inherited with other relatives a portion of the old lands. He possessed a taste for scientific pursuits, but had little time at his disposal to devote to them, being for many years fully engaged in business in London, as a manufacturing chemist, at Castle Street, Saffron Hill, until illness compelled him to discontinue his active interest in it. He served as one of the Local Commissioners for Finsbury for the Exhibition of 1851. He had been a member of the old Mathematical Society from his youth, on the introduction of his father, who had also been a member from early years; and he became a Fellow of this Royal Astronomical Society, with the other members of the Mathematical Society, in 1845.

Antoine François Joseph Yvon Villarceau was born at Vendôme, Loir-et-Cher, on January 15, 1813. After having completed his education, so far as was attainable in the college of his native town, he proceeded to Paris, soon after the Revolution of 1830, full of enthusiasm for literature, art, and music. Here he continued his studies at the Conservatoire with so much success that before leaving in 1833 he obtained a first prize. Having adopted with great fervour the peculiar doctrines of Saint-Simon, he, in the same year that he quitted the Conservatoire, accompanied Félicien David to Egypt as a member of a mission of that sect, at that time stationed there under the direction of M. Enfantin. From his association with the engineer officers of that mission, especially with his friend Lambert Bey, he first obtained a taste for those branches of mathematical and mechanical science in which he afterwards became so distinguished. Returning to Paris in 1837, he became a successful student at the École Centrale, where he remained three years.

Possessed of independent means sufficient to remove all necessity for seeking immediate employment, M. Villarceau, after completing his education at the Ecole Centrale, devoted nearly all his time to the study of analysis and geometry, so that he might have readily at hand the means of investigating the higher questions in mechanics and astronomy. As the first result of this continuous study, he, in 1845, presented a memoir to the Académie des Sciences, entitled, "Méthode de correction des éléments approchés des orbites des comètes au moyen de trois

observations," an abstract of which is inserted in the *Comptes Rendus*, vol. xx., and afterwards more fully in the *Receuil des Savants Etrangers*. This paper was received favourably by astronomers, and especially by Arago, who, struck with its originality, offered M. Villarceau the post of aide-astronome, as he had previously done to other young rising astronomers who had similarly distinguished themselves. In 1846 M. Villarceau became, therefore, a member of the staff of the Paris Observatory, to which he remained attached to the end of his life. In 1854, soon after the appointment of M. Le Verrier to the directorship of the Observatory, he was promoted to the higher and more permanent rank of astronome-titulaire, which, though not interrupting his usual duties, was the means of giving him greater facilities for continuing his mathematical researches in astronomy, geodesy, and mechanics. At this time, and for several years afterwards, he was accustomed to take a share in the ordinary daily observations, especially with the transit instrument of Gambey. He also made some observations of comets with the Equatorial, including those of Brorsen, Tempel (1859) and others.

Among the first of M. Villarceau's theoretical memoirs which attracted attention out of France were those relating to his researches on the relative orbits of double stars. Fully recognising the important labours of Savary, Encke, and Sir John Herschel on this subject, he attacked the problem with great vigour, taking advantage of the accumulated materials of former observers to calculate accurately, as examples, the orbits of several important binary systems. The first memoir connected with these researches was presented to the Académie des Sciences early in the year 1849; and it gives a mathematical explanation of the method adopted by M. Villarceau in the calculation of the orbits of several double stars, notes on which were communicated to the Academy at various times during the same year. In obtaining materials for these investigations he was greatly assisted by the MM. Struve, who liberally supplied him with several series of unpublished observations, which enabled him to calculate, by his method, the elements of the orbits of ζ *Herculis*, η *Coronæ*, and ξ *Ursæ Majoris* with great confidence. These valuable memoirs and notes are contained in the Appendix to the *Connaissance des Temps* for 1852. This Appendix also contains an elaborate paper on a "Méthode pour calculer les éléments des Planètes, ou, plus généralement, des Astres dont les orbites sont peu inclinées à l'ecliptique, fondée sur l'emploi des dérivées relatives au temps, des trois premiers ordres de la longitude géocentrique, et du premier ordre de la latitude." A more extended memoir, "Détermination des orbites des Planètes et des Comètes," is given in Vol. III. of the *Annales de l'Observatoire de Paris*. The principle of the method adopted in this investigation "is the same as that used by Laplace in his solution of the same problem; but M. Villarceau has pointed out, and skilfully discussed, the various circumstances which render a modification of

the form of solution indispensable, and has given convenient formulæ applicable to each particular case. He has also shown how the elements may be rectified, by a process of approximation founded on applying successive corrections to the coefficients of the expressions for the geocentric longitude and latitude, the values of these corrections being obtained by the solution of a system of linear equations." (*Monthly Notices*, vol. xix. p. 42.)

M. Villarceau was not slow to apply his revised method in the calculation of the elements of the orbits of several of the minor planets and comets. Elements and ephemerides of the planets *Amphitrite*, *Hebe*, *Iris*, and *Victoria* were computed with great care, and distributed among astronomers, by whom they were found to be of great value for the comparison of the tabular places with the observations of those planets. In calculating his normal positions, M. Villarceau was careful to use as many observations as he could possibly obtain, as may be gathered from the following extract from one of his notes on the planet *Victoria*. He remarks:—"To obtain still greater accuracy, I have represented graphically the comparisons published by MM. Hartnup, Carrington, Vogel, and Graham, along with those of the Observatories of Paris and Cambridge. I have also deduced comparisons from three months' observations made at Washington and collected by Mr. Ferguson. In this way I have constructed nearly 200 ordinates in Right Ascension and as many in Declination, representing the excess of observation above the computations of the ephemeris." Altogether, M. Villarceau has computed about twenty series of elements and ephemerides of the minor planets and comets. He was the first to determine the periodicity of the comet discovered by D'Arrest on June 27, 1851; and it was by the aid of an approximate ephemeris communicated by him to Mr. Màclear that this comet was detected at the Cape Observatory in December 1857, on its first predicted return to perihelion. In July 1861 M. Villarceau presented to the Academy a second series of investigations on the orbit of D'Arrest's Comet. Of other comets whose orbits have been calculated by him, the details of which are given in the *Comptes Rendus*, we need only name those of Petersen, Comet V. 1857, and the great Comet of 1858 (Donati).

In the *Comptes Rendus* for 1872, M. Villarceau has a memoir, entitled, "Sur la Constante de l'Aberration et la Vitesse de la Lumière considerée dans leurs rapports avec le mouvement absolu de translation du système solaire," in which he introduces into the theory of aberration the proper motion of the solar system, and points out that four determinations of the coefficient of aberration relative to four stars, not all situated on the same circle of the sphere, are sufficient theoretically to determine the three coordinates of the motion of the solar system, and practically to fix within the maximum limit the velocity of the Sun in space.

The Catalogue of Scientific Papers of the Royal Society,

to 1873, gives the titles of seventy-three separate papers of M. Villarceau. He is the author, however, of many more—probably more than a hundred in all; but they are by no means confined to astronomical subjects. In his mechanical papers he gives abundant evidence of his high mathematical power, in illustration of which we need only refer to his memoirs on "Arches de Pont"; "On the Theory of the Stability of Locomotives in Motion"; "On the Analytical Theory of Foucault's Gyroscope"; and to his researches on the rates and compensation of chronometers. In this last memoir (Vol. VII. of the *Annales de l'Observatoire*) he apparently shows that it is not difficult to determine by trial the six coefficients of the expression which represents the rate of a chronometer more or less compensated. His method for correcting chronometers for errors of compensation, described in this memoir, has been confirmed by Commandant De Magnac, after twelve years' comparison at sea, the details of which are given in "Traité de nouvelle Navigation astronomique."

One of the most important works undertaken by M. Le Verrier during his superintendence of the Paris Observatory, was the galvanic determination of the difference of longitude between Paris and important stations in France and neighbouring countries. That distinguished astronomer had not been in office many months when, in conjunction with the Astronomer Royal, he commenced this series of longitude operations, by determining the difference of longitude between the Observatories of Paris and Greenwich. Though M. Villarceau had very little to do with this first determination, it appears that the discussion and preparation of many of those which followed were intrusted to him, as may be seen on reference to Vol. VIII. of the *Annales*. In this volume are given full details of the operations carried on in the years 1861 to 1865, connected with the astronomical determinations of the longitudes, latitudes, and azimuths of Dunkirk, Brest, Biarritz, Madrid, Strassburg, Nantes, Talmay, &c. In each of these memoirs M. Villarceau has arranged the details in a very systematic manner, so that no difficulty is found in following the course of the whole operation from the beginning to the end. In performing this work, for which he was so well fitted, he had evidently relieved M. Le Verrier of much labour which would ordinarily have devolved upon the Director. M. Villarceau was also intrusted, under M. Le Verrier's direction, with the preparation of the plans of the great Equatorial, erected in the west tower of the Paris Observatory.

The total eclipse of the Sun of July 18, 1860, was observed by M. Villarceau and other French astronomers at Moncayo, Spain, but the results of the observations were not published till 1868, when the detailed report, printed in the *Comptes Rendus*, was presented to the Académie des Sciences.

In 1857 M. Villarceau was appointed a member of the Bureau des Longitudes, and in 1867 a member of the Académie des

Sciences in the section of Geography and Navigation. He was an Officer of the Legion of Honour, and Chevalier of the Order of Charles III. of Spain, &c. He was elected an Associate of the Royal Astronomical Society on June 10, 1853.

During the important period when the reorganisation of the Paris Observatory became necessary after the death of M. Arago, in October 1853, M. Villarceau afforded great assistance to M. Le Verrier. During a fortnight's residence at the Observatory in 1854, the writer of this notice had many opportunities of observing the personal interest that he took in the ordinary work, which then had hardly settled down to the regular routine duties which M. Le Verrier was so anxious to introduce. But it did not require many days to perceive that M. Villarceau was more at home when employed on mathematical investigation than in active work at the telescope. But perhaps this was owing partly to the physical defect of deafness, to which he was even then subject. This infirmity increased in after years, and was the means of isolating him, in some measure, from the pleasure of association with his scientific colleagues.

No one would have considered from the appearance of M. Villarceau that his end was so near. Little more than two months before his death he was selected by the French Government, with Colonel Perrier and M. Faye, to represent them as delegates to the International Geodetic Congress held at Rome in October 1883. He afterwards visited Naples, and, notwithstanding his age, he ascended Vesuvius, and was taken to the edge of the crater. It is possible that the fatigues incidental to this Italian journey may have so weakened his constitution that his strength was not sufficient to overcome the severe illness which seized him about the middle of December, from the effects of which he succumbed after only a few days' suffering. He died on December 23, 1883, at his residence in the Boulevard Saint Michel, Paris, having nearly completed the seventy-first year of his age.

E. D.

Proceedings of Observatories.

The following Reports of the proceedings of Observatories during the past year have been received by the Council from the Directors of the several Observatories.

Royal Observatory, Greenwich.

The usual meridian observations of the Sun, Moon, planets, and fundamental stars, with other stars from a selected list, have been continued with the same regularity as in past years. A new working catalogue of 2600 stars, comprising all stars down to the sixth magnitude, inclusive, which had not been observed with the Transit Circle since 1860, was brought into use last spring, and considerable progress has been made in clearing off the stars, three observations being usually required of each. About 1550 stars were observed in 1883, and special pains were taken to secure at least two observations of each of these in the year, so that mistakes of observation or reduction might be more readily detected. The whole number of transits observed during 1883 is 5318, and of circle observations 5180. Although the number of observations last year is much larger than in former years, the reductions have been kept up as closely as usual, and good progress has been made in collecting the planetary and star results for the year in the usual ledgers.

The mean error of the Moon's tabular R.A., from 100 observations with the Transit Circle in 1883, is $+0^{s}\cdot03$, Prof. Newcomb's corrections to Hansen's *Tables de la Lune* having been applied in forming the tabular places of the *Nautical Almanac*. The mean error in 1882, when Hansen's tabular places, uncorrected, were used, was $+0^{s}\cdot82$.

The new mounting of the collimators, described in the last Report, has been found to answer well. The variations in the micrometer readings from day to day are small, and the changes during the observations of collimation are practically insensible; but to avoid any possible effect from this cause it is still the rule to place the corresponding wires of the two collimators in coincidence immediately after as well as before each determination of the collimation-error of the Transit Circle.

Five determinations of the flexure of the Transit Circle were made in 1883. The mean resulting value, $-0''\cdot49$, is larger than usual. The discordance between the nadir observation and the mean of the results from reflexion-stars, north and south of the

zenith, is 0″·45 for 1883, a slight increase on the value found for the previous year.

The observations of the Moon and adjustment stars with the Altazimuth have been confined during the past year to the first and last quarter of each lunation, as it is considered that the intervening semi-lunation is sufficiently provided for by the meridian observations.

A gun-metal focussing rod, with scale reading to 1-200th of an inch, and ivory point for contact with the surface of the mercury, has been applied to the reflex-zenith-tube, and about 50 transits of *γ Draconis* have been taken during the past year for determination of the values of 1 revolution of the micrometer screw, corresponding to different temperatures and different scale-readings of the focal length, in order to obtain the correction for effect of temperature on the results with the reflex-zenith-tube.

The Equatorials have been employed for the usual extra-meridian observations. Comet *a* 1883 was observed on four days with the Sheepshanks Equatorial; and Comet *b* 1883 (Pons-Brooks) on seven days with the Sheepshanks Equatorial, and on two days with the S.E. Equatorial. Micrometric measures of the positions of five of the satellites of *Saturn—Tethys, Dione, Rhea, Titan,* and *Japetus*—have been made on six nights with the S.E. Equatorial, and of *Titan* only with the Sheepshanks Equatorial on seven nights, this telescope not being sufficiently powerful for satisfactory observation of the fainter satellites. Measures of one of the satellites of *Uranus* (*Titania*) have been obtained on one night with the S.E. Equatorial, and also some comparisons of *Polyhymnia* with neighbouring stars. Some measures of the distance and position-angle of double stars have been made on fourteen nights with the double-image micrometer mounted on the Sheepshanks or Simms Equatorial.

Nine occultations of stars by the Moon, and 37 phenomena by *Jupiter's* satellites, have been observed in 1883.

The usual spectroscopic observations have been made with the half-prism spectroscope mounted on the S.E. Equatorial. The displacement of the F, *b*, or D lines has been measured in the spectra of 46 stars, the total number of measures being 309. The chromosphere of the Sun has been examined on 25 days, several prominences being visible on each day, and the spectra of various Sun-spots on eight days. The spectrum of Comet *a* 1883 was examined on one night, and that of Comet *b* 1883 (Pons-Brooks) on two nights. The results of these observations have been given in the *Monthly Notices*. The spectrum of *η Ceti* has also been specially examined at the request of Dr. Konkoly, but the supposed existence of bright lines has not been confirmed. The reductions of all the spectroscopic observations are completed to the end of 1883.

Photographs of the Sun have been taken on 221 days in 1883, as compared with 201 in 1882, an increase which is due partly to

finer weather, and partly to the use of dry plates instead of wet. the former having been used regularly since December 1882, Sun-spots have not shown any sensible decrease as regards number or area in the year 1883, though no single spot as large as that of 1882, November 12–25, has been observed during the year. The faculæ, however, show a decided falling-off in 1883 as compared with 1882. The Greenwich photographs have all been measured in duplicate to the end of 1883, and completely reduced to November 17. Seventy-eight Indian photographs, taken at Dehra-Dûn under the superintendence of Mr. J. B. N. Hennessey, have been received from the Solar Physics Committee, to fill up the gaps in the series of Greenwich photographs between January 1 and October 19. All of these have been measured, and the measures completely reduced to September 6. One hundred and forty-two Indian photographs for the year 1882 have been measured and completely reduced, thus making the total number of 343 days for which there are photographs of the Sun available in 1882.

In the spring of 1883 an important addition was made to the instruments of the Observatory by the munificent donation of the Misses Lassell, who have presented the 2-feet Equatorial reflector which had done such good service in the hands of their late father, W. Lassell, Esq. The instrument has been erected in the South Ground, where it commands a nearly unobstructed view of the sky to within 5° of the horizon. A circular building 30 feet in diameter, to be surmounted by a dome, has been prepared to receive it. The dome, which has been constructed by Messrs. T. Cooke and Sons, is now in process of erection.

The volume of *Greenwich Observations* for 1881 was distributed in June last, and the printing of the astronomical portion of the volume for 1882 is complete with the exception of the Introduction. The Spectroscopic and Photographic Results for 1882, which include the results from the Indian photographs, are also printed. The printing of the Magnetical and Meteorological results has been a little delayed by some additions, which have been made with a view of giving fuller information as to magnetic disturbances whether of large or small amount, and of thus affording facilities for comparing them with solar phenomena.

Armagh Observatory.

During the past year very little observing has been done, most of the time having been taken up by the preparation for the press of the *Second Armagh Catalogue of* 3000 *Stars.* It is expected that the printing will commence in a few weeks.

In June the Governors of the Observatory sent a memorial to the Treasury (accompanied by a printed historical account of the institution), asking the Government to grant compensation for

the pecuniary losses to the Observatory caused by the passing of the Irish Church Act. In December an answer was returned, stating that the Lords of the Treasury had decided to insert in the estimates for the coming year the sum of 2,000*l.*, to be spent by the Governors solely on instruments or apparatus. It may thus be hoped that the instrumental equipment of the Observatory will soon be materially improved.

The working of the photographic Barograph and Thermograph was stopped at the end of the year, in consequence of the withdrawal of the greater part of the grant hitherto paid by the Meteorological Council. The self-recording rain-gauge and Anemograph remain in operation, and 9 A.M. and 9 P.M. readings are now taken as at second-class stations.

Cambridge Observatory.

A steady effort has been made throughout the past year to obtain observations of such stars in the Zone which has been assigned to this Observatory, as had been hitherto unavoidably omitted. All other work has been treated as subordinate to this. As the stars to be observed were irregularly scattered over the Zone, the actual number of observations obtained is considerably less than in former years, although the time devoted to them has been nearly the same.

The total number of meridian observations is 2289, including 248 observations of Clock Stars, 69 observations of *Polaris* above the pole, requiring 164 Circle Readings, and 70 below the pole, with 166 Circle Readings, and 1902 observations of Zone stars.

The fluctuations in the position and adjustments of the Transit Circle have kept within narrow limits, but have been carefully watched. The error of Collimation was determined 180 times, and the level error and Nadir Point were each determined 169 times.

Swift's Comet was observed on 9 nights with the Northumberland Equatoreal.

In addition to the above-mentioned work we have nearly completed a very extensive series of observations made for the purpose of testing the accuracy of the divisions in the West Circle, which is the one that has been used throughout in the Zone observations. The observations of the Standard Stars are reduced to the end of 1881, both in Right Ascension and North Polar Distance. The observations of 1882 and 1883 are in hand, and the reductions are far advanced. The true Right Ascensions and true North Polar Distances of the Zone stars are obtained to the end of 1881, and the corrections for reduction from apparent to mean places to the end of 1880.

Tables have been constructed for reducing to the epoch

1875·0, and by the aid of these the work of reduction is progressing rapidly.

The small corrections for reducing to the Berlin places of the standard stars, and for taking into account the flexure of the instrument, are calculated nearly up to the present time.

Dunsink Observatory.

On 118 nights during the year the chronograph was used in connection with the meridian circle. On only 52 nights, however, was it sufficiently clear to observe the Southern stars on the working list, varying in magnitude from about 6·5 to 10; of these, 437 satisfactory observations in Right Ascension were to be taken, and in Declination 474, all of which have been reduced to their apparent places for the date of observation. The reduction to mean places has just been commenced. Both coordinates of each star were observed at each transit, but on one or two occasions the contact in the clock or at the trigger was unsatisfactory, and in consequence the chronograph sheet illegible, which accounts for the difference between the numbers just given.

Observations of 280 standard stars were taken for determining the Right Ascensions, the zero of Declinations being on every occasion determined by Nadir observations from a mercury trough. In addition, observations of standard stars were taken on 66 nights when the weather was too bad for regular observations to determine the clock error for the time service to Dublin.

The South Equatorial has been employed as usual in observations for Annual Parallax; and Part V. of the *Dunsink Observations* is going through the press.

Royal Observatory, Edinburgh.

During the past year the daily electric distribution of true time, by ball, gun, and controlled clocks, as derived from astronomical observation, has been kept up as usual. Also the computation of the bi-diurnal meteorological observations of six towns, and fifty-five town and country stations throughout Scotland, for the monthly and quarterly returns of the Registrar-General of Births, Deaths, &c., in Scotland.

It was hoped by the Director that during the year some action would be taken with respect to the recommendations of the Board of Visitors in 1870 and 1872, and the Commissions of Enquiry in 1876 and 1879; but this hope has been disappointed. Correspondence is in progress with respect to the resumption of the printing of the Edinburgh Star Catalogue in a condensed and economical form.

On April 6 the Universities (Scotland) Bill was introduced into Parliament, by which it was proposed that the Observatory be attached to the University of Edinburgh; but it was withdrawn.

Kew Observatory.

The sketches of Sun-spots as seen projected on the photo-heliograph screen have been made on 214 days, in order to continue Schwabe's enumeration. The Sun's surface was found to be free from spots on seven of those days.

The correction to the area-measurements for foreshortening, which, at the date of the last Report, had not been applied to the reduction of Sun-spot observations for the last two years of the series, has since been made under Mr. De La Rue's direction. The whole series is at the Royal Society, and is now being revised and arranged for reference by Mr. Marth, on behalf of the Council of the Royal Society, who made a grant of money for that purpose.

One hundred and fourteen observations have been made of Sun-transits, for the purpose of obtaining correct local time at the Observatory; 224 clock and chronometer comparisons have also been made. Shelton's Clock, K.O., has been used as the standard timepiece of the Observatory.

The Committee, having decided to make a trial of a system of watch-rating for the public, have granted £100 for the preliminary expenses. In accordance with a scheme prepared by the Superintendent, and with a view to the obtaining of star-transits, they have built a temporary transit-house in a more convenient locality than the present one, in which the Sheepshanks 30-inch Transit (No. 27), lent by the Royal Astronomical Society, has been set up. An apparatus is being fitted up for rating the watches at extreme temperatures, and a circular has been drafted, which will be issued to watchmakers on the completion of these arrangements. It is hoped that operations will be commenced very shortly.

Prof. C. S. Peirce, of the United States Coast Survey, who made a series of pendulum observations at Kew and elsewhere in 1876, visited the Observatory in July last, and made a subsidiary series of experiments with a view of determining the flexure of his stand when on the Kew piers, using a noddy for the purpose.

The usual magnetical and meteorological observations and reductions, and the verification of instruments, operations to which the attention of the Observatory is mainly directed, have been carried on as formerly.

Liverpool Observatory, Bidston, Birkenhead.

The Meteorological work during the past, and for several preceding years, has been very heavy for the limited force of this Observatory, but this has not prevented due attention being paid to work connected with improvements in chronometric navigation. In addition to the testing of new chronometers for error of thermal adjustment, records of the performance of chronometers at sea for each of one hundred voyages from Liverpool to the West Coast of South America and back to Liverpool have been received and discussed at this Observatory. The rates of all the chronometers employed were corrected for change of temperature in accordance with the mean temperature obtained daily at sea. As each ship carried three chronometers there are three hundred cases in which the daily rates at sea were obtained for an average voyage of one hundred and five days. The average difference between the predicted daily rates and the rates actually made at sea was 0·37 of a second of time. In one hundred out of the three hundred cases the average difference between the predicted rates and the rates made at sea was only 0·08 of a second of time. The thermal errors of all the chronometers used were in the first instance carefully determined at Bidston.

A Report on the working of the chronometrical department of this Observatory has recently been published by the order of the Mersey Docks and Harbour Board, which shows the method had recourse to for predicting the rates on the voyages above named. The results show that when the rates are corrected for change of temperature, marine chronometers will carry on the Greenwich time at sea for three or four months as accurately as ordinary astronomical clocks on shore will carry on the time for a similar period. But when the rates are not corrected for change of temperature, the errors of chronometers at sea are, on the average, increased in the proportion of about four to one.

Radcliffe Observatory, Oxford.

Observations have been systematically made with the Transit Circle during the year 1883.

The number of observations is as follows:—

Transits	2604
Circle Observations (each requiring the reading of the four Microscopes)...	2447

These totals include :—

Observations of the Sun	54
Observations of the Moon	53
Reflexion Observation of Stars	96

and

234 Pairs of Nadir Observations

Only one observation was made of the passage of the Moon's diameter, but ten measures of the vertical diameter have been secured.

The N.P.D. reductions are finished to date, and the R.A.'s are completely reduced to September 5.

The Astronomical Results of 1881 have been printed.

The Observations for 1882 are being prepared for press.

The Nadir Points have been exclusively determined with the Nadir reflecting eyepiece; but frequent observations of stars by reflexion, North and South of the Zenith, have been made as a check upon the existence of any systematic errors.

The value of R—D, as determined from 26 Northern stars with 56 observations, is

$$-0''{\cdot}094;$$

whilst from 29 Southern stars with 57 observations, its value is

$$-0''{\cdot}284.$$

The mean discordance between the Nadir Points determined from the wire observations and from the star is therefore only

$$-\ ''{\cdot}09.$$

As another check upon the proper working of the instrument, determinations of the Nadir reading have been taken over a considerable range of the screws, and the results show that there are no serious errors in the runs of the screws.

Some R.A.'s have also been observed by reflexion to test the freedom of the instrument from systematic errors, and as far as these observations can be carried, they give no indication of such errors.

Eleven observations of Occultations of Stars by the Moon and forty-five of Phenomena of *Jupiter's* Satellites have been made with the extra-meridional instruments.

The Meteorological Results for 1881 are rapidly passing through the press. The complete volume will soon be ready for distribution.

Oxford University Observatory.

Since the last report of the work done at the Oxford University Observatory, then brought up to Feb. 1883, the expedition to Abbasseeyeh, in the neighbourhood of Cairo, for the purposes of stellar photometry has been completed, and the results have been communicated to the Society. The more interesting of these are as follows :—the climate, as was well known before, is, during the winter and early spring months, equable and dependable beyond anything known in Europe. This was shown by the fact that 3,385 extinctions of stars were made at Cairo with the wedge photometer, while only 997 were made at Oxford in the same time. The absorption of stellar light by the atmosphere was equal to $0^m{\cdot}187$ sect. Z.D., while at Oxford it is $0^m{\cdot}253$ sect. Z.D., indicating, as might be supposed, a superiority of translucency in the Egyptian atmosphere. Still, when viewed in a practical sense, this superiority is not so important as it appears at first sight, inasmuch as the minimum visibility of stars in Egypt differs from that in England, at an altitude of 30°, by only one-fifth of a magnitude. There is, however, one evident superiority in the Egyptian over the English atmosphere, that whereas it is not safe (ordinarily) to work photometrically at zenith distances greater than 60° in England, observations in Egypt may easily be continued to 75° Z.D. Since the Cairo results have been published, another determination of the absorptive power of the atmosphere has been effected by Dr. Müller, of Potsdam, with the result, that the formula $0^m{\cdot}201$ sect. Z.D. fairly represents it. The general conformity of all these results, from Bouguer and Seidel to the present day, by means of entirely different instrumental appliances and methods, is gratifying and remarkable.

The photometric measures of all the stars brighter than the fifth magnitude, extending from the Pole to a little beyond the Equator, have been completed and published by the Society in vol. xlvii. of their *Memoirs*. In addition to the photometric determination, a concise account of the methods employed for effecting the same purpose by successive astronomers from the earliest attempts to the present day has been added.

The photometric measures of all the remaining stars, within the limits described, contained in Argelander's *Uranometria*, are now being proceeded with. Considerable advance has been already made, and it is hoped that at the present rate of progress a new Uranometria will be completed in fifteen months from the present date. This will constitute the first complete attempt of the kind in our country.

Besides this continuous photometric work the measurement of the relative coordinates of forty stars of the *Pleiades* has been completed, with the duplex micrometer (together with their photometric magnitude), with a view to the discussion of their proper

motion, and the cohesion, or otherwise, of the group, as forming one system. This undertaking has involved considerable time, labour, and difficulty, owing to the necessity of examining so many catalogues of observations and of reducing the whole on one system, in accordance with the requirements of modern refinement. Probably, the memoir will be ready for presentation to the Society before it separates in June. There are necessarily considerable interruptions to these researches owing to the primary duties of the Director of the Observatory in lecturing as a University Professor.

All desirable aid is received from the assistants, Mr. W. E. Plummer and Mr. Jenkins.

Temple Observatory, Rugby.

During the year 1883, the measurement of positions and distance of double stars has been continued, 263 sets of measures of 109 double stars have been made by Messrs. Seabroke and Percy-Smith, with the Alvan Clark Refractor. The results of the last three years have been reduced, and are being prepared for printing.

Owing to an irregularity noticed in the rate of two clocks governed by pendulums having wooden rods, compensated by zinc tubes, of a length based on Captain Kater's figures for the coefficient of expansion of wood, a series of experiments on the expansion of rods of various woods was undertaken by Mr. Seabroke, with the result that the numbers usually given appear much too high.

The usual instruction has been given to members of the School, to whom the Observatory has been open for an hour every fine evening.

Stonyhurst College Observatory.

The Sun observations have now become one of the chief portions of the daily routine work of this Observatory, and results have been obtained on 202 different days. The large pictures of the whole solar surface are 185 in number, and these have been supplemented by 16 smaller pictures, and by general descriptive notes when drawings could not be obtained. It is hoped that the series of solar drawings, now extending over several years, will be measured in the course of a few months, and some results laid before the Society.

The height of every part of the chromosphere has been measured on 72 days, and a certain portion on 7 other days. The observations of spot spectra were much less numerous than those of the chromosphere; but more attention will be given to this

important branch of solar physics during the ensuing year. The unusual amount of cloudy weather has greatly interfered with night work, and only preliminary observations have been attempted with the large star spectroscope. Positions of Comet Pons were taken on October 6, 25, and 28, and on November 26. The phenomena of *Jupiter's* satellites were observed on 33 occasions, and also the occultation of *o Arietis*, on March 12.

The meteorological and magnetic departments have continued to receive the same attention as in previous years, and the continuous photographic record of the principal instruments has suffered no interruption.

Mr. Barclay's Observatory, Leyton, Essex.

The past year has been exceedingly unfavourable for Astronomical work in the Observatory, a long continuance of cloudy nights having been the rule, though the rainfall has been small, and the first four months remarkably dry.

The usual routine work has been carried on, and observations of the satellites of *Saturn* have been made when possible, Mr. Marth's Ephemerides being used.

Mr. Common's Observatory, Ealing.

During the past year attention has been chiefly given to photography. Negatives of several nebulæ have been obtained, including a series of the Great Nebula in *Orion*, using the arrangement for making long exposures completed in 1882. A 6-in. Equatorial Refractor has been mounted specially for stellar photography, and a number of different lenses tried.

Another mirror has been figured by Mr. Calver for the 3-foot telescope.

The weather during the last half of the year has been very unsuitable, and very little work has in consequence been done.

The Earl of Crawford's Observatory, Dun Echt.

Owing to the serious illness of Mr. Lohse, and the continued absence of Dr. Copeland in South America, but few observations were made in the earlier part of the past year. Still Comet 1883 I. was not allowed to pass away without careful spectroscopic observations having been made of the usual three bands on March 1. These are published in *Copernicus*, along with a few places of the returned Comet of 1812.

During the year fifteen circulars, all referring to comets, were printed at the Observatory, and widely distributed. Dr.

Swift has since found that the object mentioned in Circular 81 is in reality a nebula, the appearance of motion which led to a subsequent mistaken identification having arisen from a defect in his apparatus which he has since remedied.

The meteorological and time observations, as well as the weekly firing of the time-gun on Saturday, remain unaltered.

In August the optical resources of the Observatory received a most important augmentation through the arrival of a large grating, ruled on speculum metal, under the supervision of Professor H. A. Rowland, of Baltimore. This magnificent grating has a ruled surface of $5\frac{1}{16}$ by $3\frac{1}{2}$ inches, at the rate of 14,438 lines to the inch. With collimating and viewing telescopes of four inches aperture, a power of 120 can be advantageously used on the spectra of the second order. In this way the duplicity of D_2 was noticed, and that of D_1 suspected, independently of Professor Rowland's separation of both those lines into two components. On December 14 it was observed that the strong line wave-length 588·32, although double on the Sun's following limb, is but single on the preceding limb; the one component being due to the iron of the Sun's atmosphere; and the other, most probably, to aqueous vapour in our own, the displacement of the former line being, of course, caused by the Sun's rotation.

Dr. Copeland returned on September 1, after having established a temporary observatory at Puno, 35 feet above the surface of Lake Titicaca, and 12,540 feet above the sea. Subsequently the telescope was also erected at Vincocaya, 14,360 feet, and for a single day only at Arequipa, 7,550 feet above the ocean. The then disturbed political state of Peru in some degree impeded the progress of the work and the transmission of essential parts of the instruments; and but for the cordial and energetic kindness of Mr. John L. Thorndike, the lessee of the Puno, Mollendo, and Cuzco Railway, the difficulties encountered would have been far greater. This remarkable railway, attaining a height of 14,666 feet, was made the base of operations, and the reversed head-stock of a lathe from one of its workshops formed the Equatorial mounting with which most of the observing was done. Several close double stars were detected, *β Muscæ* and H *Velorum* being amongst the number; but the definition, although often very fine, was not greatly superior to that at a good station lower down. The chief gain was in increased transparency of the air, a measure of which may be found in the visibility of *Sirius* and *Canopus* to the naked eye before sunset. An interesting result is the discovery of several minute planetary nebulæ, by the method of sweeping with a prism attached to the eye-piece recommended by Professor Pickering, and not less interesting is the finding of a number of small stars with bright-line spectra, closely related to those of the Wolf-Rayet stars in *Cygnus*, and the establishment of the fact that the marvellous spectrum of *γ Carinæ* (*Argûs*) noticed long ago by Respighi and Le Sueur is also of

this class. These spectra gain in importance from their great resemblance to those of temporary stars. As a rule the air was very dry, the tension of aqueous vapour falling below $\frac{1}{20}$th of an inch. On one occasion the dry bulb thermometer stood at 45°·7, while the wet bulb showed 30°·6, and the solar-radiation thermometer registered 199°·1 Fahr., the boiling-point of the station (Vincocaya) being 186°·1. The Sun's corona was not certainly seen, although the strong diffused light was restricted to the immediate neighbourhood of the Sun's disk, where it very suddenly increased. This is confirmed by the observation of a spectrum with Fraunhofer lines terminating somewhat abruptly at about 5′ from the Sun's limb. A summary of these experiences was read before Section A of the British Association at Southport, and a complete Report, including all the results, is nearly ready for publication.

Mr. Edward Crossley's Observatory, Bermerside, Halifax.

The usual observations have been carried on at this Observatory throughout the year 1883. About 300 measures of binary stars were made, and about 40 of the phenomena of *Jupiter's* satellites were observed. Some of these latter observations have already appeared in the *Monthly Notices* of the Society. The usual meteorological observations have been made at 9 A.M. and 3 P.M. daily, and monthly summaries sent to the Registrar-General, &c.

A Wedge Photometer has recently been procured from Mr. Hilger, and we hope to be able to do some useful work on variable stars next year. The year 1883 proved a bad one in point of weather, the sky being clear throughout on not more than 20 nights.

Mr. Huggins' Observatory, Upper Tulse Hill, S.W.

The great Equatorial was remounted in the early part of the year. The improvements consist mainly in having had the declination made double: *i.e.* there are now two declination axes, the one moving within the other; to one is attached the refractor with an object-glass of 15 inches diameter, to the other the Cassegrain telescope, with a metallic speculum of 18 inches diameter. The double axis permits the telescopes to be moved independently of each other in declination, so that the one not in use may be so moved as not to come into contact with any part of the mounting, or to be in inconvenient positions.

Both telescopes are carried by the clock motion, and by the doing away with the counterpoise weight, the weight to be carried is not increased in a serious degree.

The photography of the Corona without an eclipse has formed the principal work since the remounting of the Equatorial. A new apparatus has been constructed which is attached to the refractor, so as to be carried by the clock motion and under the same control as the telescope itself. This consists of a 7-foot Newtonian telescope made by the late Mr. Lassell, and kindly placed in my hands by the Misses Lassell. The speculum, $7\frac{1}{4}$ inches in diameter, possesses great perfection of figure and still retains its original fine polish. The small mirror is removed and the open end of the tube fitted with a mahogany cover. In this cover, on one side is a circular hole $3\frac{1}{4}$ inches in diameter for the light to enter; below, is a similar hole, over which is fitted a framework to receive the "backs" to hold the photographic plates, and also a frame with fine ground glass for putting the apparatus into position. Immediately below, towards the speculum and very near the focal plane, is fixed a shutter with an opening of adjustable width, which can be made to pass across more or less rapidly by the use of indiarubber bands of different degrees of strength. In front of the opening through which the light enters is fixed a tube about 6 feet long, fitted with a large number of diaphragms. It is obvious that if the apparatus be so directed that the light passing through the upper opening falls upon the middle part of the speculum, which alone comes into use, the image of the Sun will be formed in the middle of the lower opening, about 2 inches from the position it would occupy if the tube were directed axially to the Sun.

Cells containing coloured fluids have been discarded in consequence of the rapid decomposition of the fluids under the Sun's light, and the formation of a fine deposit on the surfaces of the plates which would scatter light, and might also give rise to misleading appearances in the photographs. The selective power of the coloured cells was sought to be obtained in the sensitive film itself, and it was found that the silver chloride emulsion was very sensitive for this purpose. Disks of brass were made of such a size as to be in a minute degree larger than the Sun's image.

About fifty photographs were taken between April 2 and Sept. 4. Some were taken with the Sun covered with the brass disks, some without. In some cases the Sun was in the centre of the field; in other cases several photographs were taken with the Sun towards different sides of the field. All these plates show a more or less coronal appearance about the Sun. The plates are now in Mr. Wesley's hands, who is making drawings from them. In three plates taken about the period of the eclipse, a strong rift is seen which is similar to the main feature in the photographs taken at Caroline Island during the eclipse of May 6.

The Earl of Rosse's Observatory, Birr Castle.

Astronomical observations were made on 64 nights.

In the earlier part of the year twenty-four complete drawings of the planet *Jupiter* were made, besides a few sketches of parts of the planet's surface. The 3-foot Reflector was the instrument employed.

Nebulæ were observed, and a few sketches made, early in the year with the 6-foot Reflector under very unfavourable circumstances, owing to the condition of the speculum at that time.

In August a new machine for polishing 6-foot specula was completed. It is similar in construction (except as to the mode of tilting the speculum for testing) to that constructed for the 3-foot specula in the previous year. The speculum was polished with it successfully so far as it was tested, but the weather has been so exceedingly unfavourable during the latter part of the year that it was not possible to try it on test objects so fully as was wished.

The addition to the driving-clock of the 3-foot telescope of an escapement under the electric control of a clock in the Observatory, affords great assistance and great comfort in various classes of observations with that instrument.

Some photographs of stars have been taken with various exposures, and two or three unsuccessful attempts to obtain an image of the Great Nebula in *Orion* were made. Owing to the greater focal length of the 3-foot Reflector as compared with that of Mr. Common, three times the exposure that was required to produce his well-known plate was in one case given, but from the appearance of the stars in the negative it would seem that, whether owing to greater intensity of light in the primary image, or to a lesser sensitiveness, or a difference of treatment of the dry plate, the result was not equivalent to that of his or the late Prof. Draper's photograph.

Of late an unusually cloudy sky, accompanied by unusually poor definition has impeded us in all our observations. It is somewhat remarkable that not a single sketch of the planet *Jupiter* has been made since its reappearance last autumn, and this is at least as much due to unusually bad definition as to the interference of photographic and other work.

The historical and critical discussion of the literature "On the Influence of Magnetism on the Rate of a Chronometer," by Dr. Boeddicker, alluded to in our last Report, has since been published in the *Scientific Transactions* of the Royal Dublin Society.

The meteorological department has been carried on, as in the previous year, without change.

Colonel Tomline's Observatory.

The period over which the following report extends is from January 1882 to December 1883, with the exception of four months, during which time the observer was engaged in the work of observing the Transit of *Venus*, at Bermuda. The Equatorial has throughout been entirely devoted to the observation of comets, four of which have been followed in the interval, namely:—

Comet I. 1882	From Mar. 24 to June 3	42 evenings
„ III. 1882	„ Sept. 22	1 „
„ I. 1883	„ Mar. 3 to Apr. 9	11 „
„ Pons 1812	„ Sept. 8 to Dec. 23	24 „

the last being still under observation.

The reduction of the later observations are in an advanced state, but their publication is delayed principally by the difficulty of obtaining satisfactory places of comparison stars. It is found that fully 22 per cent. of the stars selected for comparison with comets are not previously observed on the meridian; and in accordance with a plan always adhered to, no observations are published until the whole of these have been identified, and micrometrically compared with some neighbouring known star.

In spite of these drawbacks some progress has been made in bringing up arrears, the following observations of comets having been published in the *Astronomische Nachrichten* during the period under consideration.

Comet II. 1879	6 observations, made between		June 26 and	July 24
„ IV. 1879	3	„ „	Sept. 8 „	Sept. 15
„ V. 1879	13	„ „	Sept. 10 „	Oct. 15
„ II. 1880	13	„ „	Apr. 30 „	Sept. 9
„ III. 1880	11	„ „	Oct. 18 „	Nov. 25
„ V. 1880	7	„ „	Dec. 21 „	Jan. 31
„ III. 1881	45	„ „	June 24 „	Nov. 17
„ IV. 1881	13	„ „	July 27 „	Aug. 28
„ I. 1882	42	„ „	Mar. 24 „	June 3

In future our efforts to maintain the reductions to date will be continued, it is hoped with greater success.

Royal Observatory, Cape of Good Hope.

During the past year the work of the Observatory has been confined to the completion of the programme announced in the *Monthly Notices* for March, 1883.

H. M. Astronomer has reached England on leave of absence, and brings with him for publication the following works in MSS.:—

1. A Catalogue of 4810 Stars reduced to the Equinox 1850·0 from observations made under the superintendence of Sir T. Maclear in the years 1849, 1850, 1851, and 1852. The work of reduction was begun under the direction of Mr. Stone, and has been carried to completion by Mr. Gill.

2. 512 Occultations of Stars by the Moon observed between the years 1834 and 1881 at the Royal Observatory, Cape of Good Hope; reduced, and compared with Hansen's Tables.

3. An account of the Telegraphic Longitude operations connecting Aden and the Cape.

4. Results of Meridian Observations for 1879, 1880, and 1881.

5. Results of Extra-Meridian Observations for 1881, 1882, and 1883.

The series of observations undertaken with Mr. Gill's Heliometer has been brought to a close. The results have been presented to the Society, and will appear in the next volume of the *Memoirs*. This memoir contains investigations on the parallax of the following stars:

α *Centauri*, independently investigated by Gill and Elkin, each observer employing two pairs of comparison stars (four pairs in all).

Sirius, both by Gill and Elkin, each observer employing different comparison stars.

ϵ *Indi*, by Gill and Elkin, each observer employing different comparison stars.

Gill investigates also the parallax of β *Centauri*, Lacaille 9352, and o_2 *Eridani*.

Elkin investigates the parallax of ζ *Toucani*, *e Eridani*, and *Canopus*.

The observations of the Great Comet of 1882 are reduced, and a memoir on the subject is nearly ready for press.

The observations of *Victoria* and *Sappho* are still unreduced. The pressure of work in clearing off arrears of publication has made it impossible to undertake the reductions in question—besides which, all of the series of observations that have been made have not yet been received. Mr. Gill will undertake this work so soon as he returns to the Cape.

The meridian observations of 331 standard stars for the future Zone observations of Professor Schönfeld's *Durchmusterung*, and of specially selected stars observed for refraction in conjunction

with Prof. Bakhuyzen at Leiden, have been completed. The meridian observations of the stars used in the longitude operations, of stars observed with comets, of comparison stars in the Heliometer parallax determinations and of other miscellaneous stars of the working list have also been completed.

The Transit Circle Observing List, begun 1884, Feb. 1, contains all stars in the southern hemisphere to fourth magnitude inclusive, all stars of the *Nautical Almanac*, and of the Berlin, Paris, and American Ephemerides to N.P.D. 45°; it also provides for daily observation of the Sun, *Venus*, and *Mercury*.

The new Collimators, which permit observation by reflection to 70° Zenith Distance, have been mounted. All stars will now be observed direct and reflex on alternate days.

The Geodetic Survey of South Africa which has been urged upon the Governments of the Cape and Natal by H.M. Astronomer since 1879, has at last been fairly begun. Captain Morris, R.E., with Lieut. Laffan and fourteen Sappers, arrived at the Cape in June 1883. The first base line has been measured in Natal, and the bars have been compared with the Observatory standard. A short account of these operations will be communicated to the Society.

The great 3-foot Theodolite lent by the Indian Government to H.M. Astronomer, has been sent to England for some alterations which will be made under the superintendence of Mr. Gill. The instrument, after these alterations, will be admirably adapted for the investigations on refraction to which it will be devoted.

Tide gauges at Table Bay, Port Elizabeth, East London, Port Alfred, and Durban have been established on the recommendation of Mr. Gill. The direction of the tidal observations at Durban is transferred to Mr. Neison, Government Astronomer of Natal; that of the other Stations remains under the direction of Mr. Gill.

The system of Time Signals has been further extended and improved.

The meteorological observations made in the year 1882 at the Observatory, together with those made in different parts of the colony, have been printed in the Reports of the Cape Meteorological Commission.

Dr. Elkin, who resided at the Observatory from the beginning of 1881 till the middle of 1883 as Mr. Gill's guest and friend, has left the Cape and accepted the charge of the new Heliometer at Yale College, New Haven, U.S. His work at the Cape has been from first to last a labour of love.

Notes on some Points connected with the Progress of Astronomy during the past Year.

Discovery of Minor Planets.

The following four minor planets were discovered in the year 1883—two by M. Palisa, and one each by M. Borrelly and Dr. C. H. F. Peters:—

No.	Name of Planet.	Date of Discovery. 1883.	Discoverer.	Place of Discovery.
(232)	Russia	Jan. 31	Palisa	Vienna
(233)	Asterope	May 11	Borrelly	Marseilles
(234)	Barbara	Aug. 12	Peters	Clinton, U.S.
(235)	Carolina	Nov. 28	Palisa	Vienna

Ten planets discovered in preceding years have been recently named—

(220) Stephania	(224) Oceana	(228) Agathe
(221) Eos	(225) Henrietta	(229) Adelinda
(222) Lucia	(226) Weringia	(231) Vindobona
(223) Rosa		

The Supplement to the *Berliner Jahrbuch* for 1886 contains 26 daily ephemerides of the minor planets for 1884, the R.A. and Declination being given for Berlin mean midnight. These are fewer than usual, but many more will doubtless be issued in the *Jahrbuch* Circulars later in the year. Much attention appears to have been given to the calculation of the 20-day ephemerides, of which there are no less than 231, those omitted being for *Hersilia* and the four lately-discovered planets. There do not appear to be many cases of near approach to the Earth, four planets only coming within the mean distance of the Sun. These are *Æthra*, whose least distance near opposition is about 0·87; *Medusa*, 0·90; *Asia*, 0·97; and *Elsa*, 0·98.

The Comets of 1883.

Three comets have been observed during the year, of which one is the great comet of September 1882, already mentioned in the last Annual Report.

The continued observation of this comet has been principally confined to the southern hemisphere; and notwithstanding the gradually diminishing brilliancy, this comet was seen, at Cordoba, up to June 1. At this date the distance of the comet from the Sun was 4·5 times the Earth's distance, and the true anomaly was about 175°. The determination of the orbit that will represent the path of this comet, through this unusually long period, with the accuracy usually sought in modern investigations has not yet been effected, and consequently the mean motion is still in some measure doubtful, though there can be little doubt but that it corresponds to a period of between 700 and 800 years. Inclined at an angle of 38° to the elliptic, the comet must soon pass out of the range of planetary perturbation, and therefore the observations should furnish an example of pure and undisturbed elliptic motion; but, as intimated in the last Report, the shifting form of the nucleus, and the different points selected for observation by different observers, have introduced unusual difficulties in the formation of normal places, and therefore the application of the usual method of equations of condition cannot here be successfully applied. Dr. Morrison, whose calculations on this subject are perhaps the most thorough yet published, has preferred to rest his calculations on three selected positions between September and November, when the character of the nucleus was tolerably well defined, and to draw an ellipse through these. By this means he has succeeded in representing the motion of the comet, from the date of its discovery up to the beginning of December, with the utmost accuracy, and finds that the observations both before and after perihelion can be represented by a continuous curve. With the later observations, however, residuals of very considerable amount occur, and exceed the amount of error that it is suggested is introduced by the varying form of the nucleus. The amount of error occasioned by this circumstance is placed by Dr. Morrison at 30″ in R.A., and much less in declination, but errors of double this amount occur between the computed places and the observations which he has selected. Whether the residuals can be reduced or not, it is certain that the alteration in the elements will be very trifling, and consequently the period of 712 years assigned by the calculation will be but little changed. With this period there is some probability that this comet is another apparition of one that is recorded in the catalogues as having been seen in B.C. 370, and possibly again in A.D. 1131 or 1132.

On Feb. 23, shortly after the rising of a nearly full Moon, Mr. W. R. Brooks, of Phelps, N.Y., detected a telescopic comet not far from *β Pegasi*. The motion, nearly due east, carried the comet through *Andromeda* into *Aries* and *Taurus*, and therefore the comet always remained near the evening twilight. Moreover, the comet had already passed its perihelion passage, and as the distance from the Earth was also increasing, it remained an inconspicuous object. Observations were continued at several

Observatories up to early in April, but as the orbit does not resemble any previously computed, and does not show any signs of eccentricity, but little interest attaches to this comet. The spectrum was of the ordinary three-band type.

On Sept. 1 Mr. Brooks discovered a second comet, of extreme faintness, and situated in the constellation *Draco*. When it had been sufficiently observed, and an approximate parabolic orbit derived, it was at once evident that this object was a second apparition of the comet of 1812. The result of the discussion of the original observations of Pons' Comet by MM. Schulhof and Bossert was to place the approaching perihelion passage in the following September, or about 220 days later than it actually occurred. A closer agreement could scarcely have been expected, seeing that in 1812 the observations, extending over barely two months, did not suffice for an accurate determination of the mean motion and eccentricity. MM. Schulhof and Bossert have shown, however, that by an alteration of only −0·0002700 in the eccentricity, their resulting elements would have been sufficiently close to represent the observations with a fair amount of accuracy. Making this alteration, the deduced elements from 1812, and those derived from observations up to Jan. 9, are as follows (the altered eccentricity being retained, since the observations hitherto made are not sufficient to correct it) :—

	Orbit from 1812 Observations.		Orbit from 1883 Observations.	
T	...		1884, Jan. 25, 7546, Berlin	
$\pi-\Omega$	199° 12′ 32″·5		199° 11′ 33″·2	
Ω	254 6 15·3	Eq. 1880.	254 5 42·3	Eq. 1880.
i	74 3 20·4		74 2 35·7	
e	0·9549960		0·9549960	
log. q.	9·8893650		9·8897099	

The recognition of the identity of this comet with that of Pons' might have been effected earlier had M. Schulhof begun the sweeping ephemeris at a greater angle from perihelion. This ephemeris commenced at a true anomaly of −97° 30′, and the comet was actually found at an anomaly of −113°. The comet has now passed into the southern hemisphere, where it will probably be visible till next June.

Although the brilliancy of the comet has increased till it has become a fairly conspicuous object in the south-western sky, this increase has not been effected steadily, and in accordance with the theoretical law. M. Bigourdan has stated that between Sept. 5 and 24 the increase in the brilliancy of the comet was thirty or forty times greater than would have resulted from reflected light alone. Mr. Chandler, of Harvard, from a comparison of his own observations with those of Prof. Schiaparelli, has, however, decided the time of the outburst within much nar-

rower limits, and fixes it between Sept. 22, $7^h\ 45^m$ and $11^h\ 45^m$ G.M.T. Another outburst has been actually watched by Dr. Müller, of Potsdam, and rigorously recorded by observations with a Zöllner's photometer. By these observations it is shown that in an hour and three quarters, on the evening of Jan. 1, the comet increased in brilliancy about seven-tenths of a magnitude, and diminished again to about its original lustre, simultaneous changes in the form of the nucleus being not less remarkable than the alteration in brightness.

In addition to these comets, it may be mentioned that two others of short period have passed through their perihelion, but owing to unfavourable circumstances have not been seen. One, Tempel's Comet of 1873, passed its perihelion on Nov. 20; the other, that of D'Arrest, made its closest approach to the Sun on Jan. 13 of this year. The theoretical brilliancy in both cases was very small, and when at the maximum the elongation from the Sun inconsiderable.

Lastly, Mr. Ellery telegraphs from Melbourne the discovery of a comet on Jan. 12, in the constellation *Grus*, but it seems not improbable that it will not be visible in the northern hemisphere.

W. E. P.

The Total Solar Eclipse of 1883, *May* 6.

This Eclipse was satisfactorily observed by all the astronomers who went out to Caroline Island for that purpose.

Circumstances prevented any regular expedition being sent out by this country, and the action of the Royal Society and the Solar Physics Committee was confined to photographic work. For this purpose Mr. Lawrance and Mr. Woods were sent to carry out a photographic attack which had been carefully and systematically planned by Mr. Norman Lockyer and Captain Abney. Through the courtesy of the American astronomers, Messrs. Lawrance and Woods accompanied the U.S. expedition, under the direction of Prof. E. S. Holden, of the Washburn Observatory, Madison.

The following photographs have been secured by them :—

1. Six good photographs of the corona, exposures varying from two to sixty seconds, giving coronal detail from near the limb to end of streamers. That the limit of the corona has been photographed is shown by the manner in which the light of the sky has impressed itself on the plate.

2. Three large photographs showing the details of the corona close to the limb.

3. Good photographs of the spectrum of the corona, showing a great number of coronal lines and very faint Fraunhoferic lines.

4. Photographs taken on a moving plate in integrating spec-

troscope from one minute before to one and a half minute after totality, showing the most prominent lines of the *reversion* spectrum. These lines belong mainly to hydrogen.

5. Photographs taken with a grating before, during, and after totality. These show H and K near the limb throughout the whole of totality.

6. Photographs taken with a dense prism spectroscope before, during, and after totality. These photographs also give some of the prominent lines of the *reversion* spectrum.

7. Two photographs taken on plates sensitive to ultra-red rays. Results comparatively indifferent, on account of the absence of prominences.

The American astronomers also secured some important results. Prof. E. S. Holden's search for intra-Mercurial planets had a purely negative result. Dr. C. S. Hastings' spectroscopic observations are of great interest. He used a 60° prism attached to a $6\frac{1}{4}$-inch Equatorial, there being two total reflecting prisms placed outside the slit, so that the spectrum of two opposite sides of the Sun could be brought into juxtaposition and simultaneously examined. This was used to note the appearance of the 1474 K line. It was found that at the beginning of totality the 1474 K line on the eastern limb was about 12° in length and very bright, while on the western limb it was 4° in length and very faint. As the eclipse progressed this inequality vanished; the two lines became sensibly equal at mid-eclipse, while at the close of totality the conditions of the beginning were again noted, the line on the western limb being the longer and brighter. Since so large a change is much greater than would be due to the Moon's motion alone, the observation is regarded by Dr. Hastings as furnishing conclusive proof that the outer corona is in the main due to diffraction, that is, that the true corona is confined to a very narrow ring around the Sun, whilst the exterior portions are simply a diffraction phenomenon, the true corona being optically widened out by diffraction at the limb of the Moon. Dr. Hastings' conclusion has been challenged, and the solution of the question must probably depend upon observations at future total eclipses, or upon the success which may attend the efforts to photograph the corona without an eclipse.

The results obtained by the Continental astronomers MM. Janssen, Tacchini, Palisa and Trouvelot are no less important and interesting.*

From his spectroscopic observations M. Janssen concludes that "the basis of the coronal spectrum was formed by the complete Fraunhofer spectrum, and that, therefore, there exists in the corona, and above all in certain localities of it, an enormous amount of reflected light; and since we know that the coronal atmosphere is very rare, it follows that these regions

* *Comptes Rendus*, vol. xcii., No. 10.

must abound in cosmic matter in the state of solid corpuscles, in order to explain this abundance of reflected sunlight."

The series of photographs obtained by M. Janssen are stated by him to show a much greater extension of the corona than was visible in the telescope; the photographic corona is well defined, and shows a large amount of detail.

M. Tacchini's spectroscopic observations are important, as he believes that he recognised in the spectrum of one streamer of the corona two of the bands—namely, that in the green and that in the yellow—so well known as characterising the spectra of comets. It will be of great importance if this observation can be confirmed at future eclipses.

On the whole the eclipse of 1883 was most successfully observed; and, apart from the purely solar phenomena, the evidence is pretty conclusive that no intra-Mercurial planet exists which is brighter than a fifth magnitude star.

The Transit of Venus, 1882.

The observations received consist of seventy-three observations of contact—viz., thirty-four at Ingress and thirty-nine at Egress—divided into the following groups :—

	Ingress.	Egress.
With 6-in. telescopes	16	11
„ 3-in. to 6-in. telescopes ...	11	23
„ less than 3-in. telescopes .	7	5

The observations were made at the following stations :—

Ingress only.

Madagascar; Cape of Good Hope, Royal Observatory, and at Montagu Road and Aberdeen Road; Natal, Durban, and Mauritius.

Ingress and Egress.

Jamaica, Barbados, Bermuda, Straits of Magellan, and two stations in Canada.

Egress only.

Two stations in Canada, Melbourne, Adelaide, Hobart, and at eight stations in New Zealand.

The whole of the time determinations for these contacts are satisfactory, and the clock errors, rates, and local times of contacts, are now determined.

The latitudes and longitudes of the various stations are also determined, except for the station at the Straits of Magellan, the longitude of the neighbouring German station being required to

complete this. The difference of longitude between Burnham and Mount Cook Observatory was carefully determined by Lieut.-Colonel Tupman, who also connected his station at Burnham by telegraph with Sydney. The signals received and sent by the Sydney Observatory have, however, not yet been received; but a determination of the difference of longitude between Mount Cook Observatory and Sydney is in progress, and the result expected by next mail. The differences of longitude between Mount Cook Observatory and the other New Zealand stations have all been determined. The tabular reductions are now in hand, and will be rapidly completed.

The telegraphic determinations of the longitudes of the Australian stations have long been under discussion, but no definite arrangements had been made until after the meeting of the Board of Visitors at the Greenwich Observatory in 1882, June, when the matter was placed in the hands of Mr. Stone. It was then found that Mr. Todd was willing and able, with the co-operation of Messrs. Ellery and Russell, to undertake the Australian work if an observer could be sent to Singapore. The distribution of the observers for the Transit of *Venus* had then been made, and some difficulty was experienced in finding anyone able and willing to undertake the work. Ultimately, although with some difficulty in the way of securing the necessary extension of leave of absence, the work was undertaken by Captain, now Major, Darwin, R.E., and it could not have fallen into more efficient hands. Captain Darwin while in Australia determined the difference of personal equation between the Australian observer and himself, and then returned *viâ* Singapore. Signals were exchanged between Captain Darwin at Singapore and Mr. Barrachi at Port Darwin on eight nights, and the results are very accordant. The telegraphic arrangements were in charge of Mr. Todd of Adelaide, and the whole of the arrangements of the Australian continent were under the direction of Messrs. Todd, Ellery, and Russell.

The longitude of Singapore had been determined by Dr. Oudemans, and Lieutenant Green of the U.S. Navy.

Taking the longitude of Madras $5^h\ 20^m\ 59^s{\cdot}35$ E., and giving double weight to Lieutenant Green's determination of the longitude of Singapore, we get—

		h	m	s
Singapore, East of Greenwich	... ...	6	55	24·69
Port Darwin	,, ...	8	43	22·21
Adelaide	,, ...	9	14	20·08
Melbourne	,, ...	9	39	53·83
Sydney *	,, ...	10	4	48·93

The longitude of the station at Madagascar (Nos Vey) was

* Mr. Russell, in a report just received, gives the longitude of Sydney $10^h\ 4^m\ 50^s{\cdot}81$ E. from seven years' observations of the Moon; Mr. Stone from two years' observations of the Moon, obtained $10^h\ 4^m\ 47^s{\cdot}32$ E.

determined by chronometer runs to and from Natal, obtaining time at Natal direct from the Cape of Good Hope Observatory. The result is—

	h	m	s
Madagascar (Nos Vey) East of Greenwich	2	54	24·01

The difference of longitude between the Bermuda station and Washington was also determined by chronometer runs to and from New York, Washington time being telegraphed to New York; the result, which agrees very closely with the Admiralty determination, is—

	h	m	s
Bermuda (Gibb's Hill) West of Greenwich	4	19	20·45

Transits of Mercury, 1677–1881.

During the last few years a most important series of astronomical Papers prepared for the use of the *American Ephemeris and Nautical Almanac* has been published under the direction of Prof. Simon Newcomb. The objects of the series of papers are a systematic determination of the constants of astronomy from the best existing data, a re-investigation of the theories of the celestial motions, and the preparation of the tables, formulæ, and precepts for the construction of Ephemerides and for other applications of the results.

The first volume, which is just completed, consists of the following papers, some of which have already been noticed by the Council:—

1. "On the Recurrence of Solar Eclipses, with Tables of Eclipses from B.C. 700 to A.D. 2300," by Simon Newcomb.

2. "A Transformation of Hansen's Lunar Theory compared with the Theory of Delaunay," by Simon Newcomb aided by John Meier.

3. "Experimental Determination of the Velocity of Light made at the U. S. Naval Academy, Annapolis," by Albert A. Michelson.

4. "Catalogue of 1098 Standard Clock and Zodiacal Stars," prepared under the direction of Simon Newcomb.

5. "On Gauss's Method of Computing Secular Perturbations, with an Application to the Action of *Venus* on *Mercury*," by George W. Hill.

6. "Discussion of observed Transits of *Mercury* 1677–1881," by Simon Newcomb.

In addition to these, there is a preface by Prof. Newcomb giving a very able account of the present state of our theories of the celestial motions.

The concluding paper is devoted to a new and exhaustive discussion of observed Transits of *Mercury*, undertaken for the following reasons. The series of Transits of *Mercury* discussed

by Le Verrier terminated with that of 1848. The fact that a third of a century of observations, far more accurate than any made in previous times, are now available is one reason for ascertaining whether any modification of his results is now possible. Transits of *Mercury* also help to decide several questions. Among these is the question of the uniformity of the Earth's rotation. The discrepancies between theory and observation in the Moon's secular acceleration, and the inequalities of long period of its longitude, give rise to the question whether the rotation of the Earth itself may not be variable. The question whether the apparent discrepancies in the Moon's motion are to be accounted for in this way can best be settled by observations on other rapidly-moving bodies. Transits of *Mercury* afford data also for the solution of those questions of the phenomena of contact which have to be interpreted and discussed in observations of Transits of *Venus*.

In the present paper Prof. Newcomb has endeavoured to work out, collate, and compare the results of theory and observation so that astronomers of the future may be able to see how they are to be reconciled without the necessity of going over the entire discussion from the beginning.

In the selection of observations available, considerable discrimination had to be exercised. The rule adopted was to retain all observations of known observers, and all made at well-known observatories or stations even when the observer was not known as an experienced astronomer, but as a rule to leave out of consideration those of unknown observers at stations whose longitude would be difficult to determine.

On the important questions of the distinction of phases and the methods of deducing the time of contact from the observations, there is of course a great deal to be said and various opinions may be formed. The author states that all experience concurs in showing that in actual observation no such distinct classification into the two phases of tangency of limbs and formation of the thread of light is possible. No tendency of the observations to group about any particular phase is found, and the conclusion arrived at is, that it is useless to attempt any investigation of phases, and that the proper course is to take an indiscriminate mean of the results of all observers irrespective of their description, except in those cases where there was something clearly different from true contact observed. Where observers assign different times, the phases corresponding to these times must be different, and these differences have to go in with the probable error of the final result. Upon this principle observations are rejected or corrected when it appears probable that they did not, or could not, correspond to the general mean.

In such an investigation, where the probable error of the observations is from 5^s to 10^s, absolute precision in the determination of the longitudes of the observers is not necessary. The Table of Longitudes of observing stations has been obtained from various published sources.

The Tabular Summary of Observations is arranged in chronological order and contains the recorded observations of sixteen November, and seven May Transits of *Mercury*, giving the station, names of observers, description of phase, time as given by the observer (which is generally apparent time before 1800, and mean time since), reduction to geocentric phase, and concluded Greenwich mean time of geocentric contact.

Part II. of the paper is devoted to the computation of tabular elements. For the purpose of deriving the time of contact and other results from the tabular positions, Prof. Newcomb has adopted a method founded on Bessel's theory of eclipses. By this method the time of contact is defined as that when the observer is on the conical surface touching the planet and the Sun. Of the two circumscribing cones, that whose vertex is between the interior planet and the Earth will correspond to internal contact, and that whose vertex is between the planet and the Sun to external contact.

In the discussion of the results, which forms Part III., two important questions are considered :—

1. Do the Transits of *Mercury* prove or disprove the hypothesis of the variability of the Earth's axial rotation ?

2. What are the possible causes of the excess of motion of the perihelion of *Mercury ?*

In the discussion of the first question a term is introduced depending on hypothetical variations of the Earth's rotation. Taking as the standard of time the Earth's axial rotation between 1750 and 1850, and assuming that the observed inequalities in the Moon's mean motion are to be accounted for by actual inequalities in the Earth's rotation, then our measurement of time would be in error by amounts varying from 17 seconds in one direction to 17 seconds in the other direction between 1723 and 1881. A table is given showing the amount of these errors when interpolated to the times of the several observed Transits of *Mercury*. The values of Δt are assumed to be multiplied by a constant factor κ, and from the equations of condition, a value of κ is found which best satisfies the observations. If the hypothesis of perfect uniformity in the Earth's rotation be the true one, $\kappa = 0$; if the observed inequalities in the Moon's mean motion arise from the cause supposed, $\kappa = 1$; if κ should come out different from either zero or unity by an amount greater than its possible error, it would arise from errors of observation or a combination of both hypotheses. The value found is $\kappa = +0{\cdot}295$. The three cases of $\kappa = 0$, $\kappa = +0{\cdot}295$, and $\kappa = 1$, are then discussed, and a conclusion arrived at that "Inequalities in the motion of the Moon not accounted for by the theory of gravitation really exist, and exist in such a way that the mean motion of the Moon between 1800 and 1875 was really less than it was between 1720 and 1800."

In the discussion of the motion of the perihelion of *Mercury* some important results are arrived at. Adopting for the mass

of *Mercury* $\frac{1}{4500000}$, which is a large diminution from Le Verrier's value, and for the mass of *Venus* $\frac{1}{400000}$, Prof. Newcomb concludes that the discordance between the observed and theoretical motions of the perihelion of *Mercury* first pointed out by Le Verrier really exists, and is, indeed, larger than he supposed. And in determining the excess of motion he concludes that "the observed centennial motion of the perihelion is greater by 43″ than the theoretical motion computed from the best attainable masses of the planet." In seeking for a possible explanation of this excess of motion, the author considers several arguments which have been brought forward—such as a possible term of very long period; Le Verrier's hypothesis of a planet or group of planets between *Mercury* and the Sun; the Zodiacal Light; a possible ellipticity of the Sun or his atmosphere; a ring round the Sun; any modification of the law of gravitation; Weber's electro-dynamic theory; all of which are rejected, and he concludes that, "assuming that we are still to look to a more exact determination of the astronomical character of the phenomena for a solution of the question, the necessary steps are, an exact determination of the mass of *Venus* from the periodic perturbation of the inner planets; an investigation of the secular motions of the planes of the orbits of those planets; and the comparison of the theoretical and observed secular motion of the perihelion of *Venus*."

In the concluding chapter on the Law of Recurrence of Transits of *Mercury*, Prof. Newcomb thus briefly indicates the high importance that should be attached to observations of that phenomenon. "Until the question of possible changes in the Earth's axial rotation shall be placed on a firm basis, or until the theory of the Moon's mean motion shall be so perfected that these changes can be determined with precision from observations of that satellite, transits of *Mercury* must be regarded with the greatest interest as affording independent determinations of the variations in question. The November Transits will long be most favourable for this purpose, for the reason that the series of observed November Transits extends back nearly a century before the first well-observed May Transit. It is to them, therefore, that we must principally look for light upon this question."

This discussion of Prof. Newcomb's forms a most important contribution to astronomy, and the results he arrives at, and the suggestions he makes, deserve the careful consideration of all astronomers. E. B. K.

The Constant of Aberration.

One of the most important contributions of recent years to observational astronomy comes from M. Magnus Nyrén, of the Imperial Observatory, Pulkowa, in the form of two remarkable

and independent determinations of the Constant, or *Maximum* value, of Stellar Aberration.

Sure indications had been obtained, from other series of observations at Pulkowa, that the classic determination by W. Struve required an augmentation greatly exceeding in amount the probable error deduced by him. As long ago as 1872, M. Otto Struve admitted that a careful re-determination of this constant was very desirable, owing to the possible existence of small systematic errors caused by inequalities of short period in the rate of the clock employed by his father, and variations, also of short period, in the azimuthal position of the horizontal axis of the Transit instrument.

The seven stars used by W. Struve gave the following individual results:—

	Constant of Aberration.	Probable Error.
	″	″
υ Ursæ Majoris	20·457	0·030
ι Draconis	20·479	0·022
δ Cassiopeiæ	20·456	0·046
o Draconis	20·403	0·023
b Draconis	20·504	0·032
Piazzi XIX. 371	20·395	0·033
β Cassiopeiæ	20·423	0·035

From which he derived the mean value $20''{\cdot}445 \pm 0''{\cdot}011$.

He subsequently considered the value $20''{\cdot}463 \pm 0''{\cdot}012$ to be a more accurate inference from the observations; but his reasons appear to have been not generally considered conclusive.

M. Nyrén takes notice of the fact, first pointed out by the late M. Yvon Villarceau, that in order to determine rigorously the Constant of Aberration it is indispensable to take account of the movement of translation of the Solar System. Attributing to the latter an annual value probably not exceeding the diameter of the orbit of the Earth, he finds the maximum effect upon the Constant of Aberration to be only $0''{\cdot}00006$, and that, therefore, there is nothing to fear from this cause in a result deduced from modern observations.

The instrument used by M. Nyrén was the same as Struve used. It had been supplied with a new micrometer eyepiece and sensitive level. The construction of the new micrometer enabled the inclination of the movable to the fixed wires to be corrected, which was not possible formerly. The fixed wires, about 37″ apart, were in groups of seven on either side of the central wire, from which they were distant about 110″. Struve's method of observing was strictly adhered to. A transit having been observed over the wires on one side of the field, the instrument was reversed and the star again observed over the same wires. The same being done on the other side of the meridian, a complete observation was obtained. There were two wires 37″ apart

movable by the micrometer screw, and when it was necessary to use these wires, they were placed in the position required and not moved until the transits on that side of the meridian were completed.

During an observation the level was left resting on the pivots, and was not reversed except with the instrument. With each complete observation were 8 readings of the level—one before and one after each of the four transits. Care was taken to keep the level error within a few tenths of a second.

A clock by Dent, having a very regular rate of its own, was employed for the observations; but to guard against small variations of its rate it was compared with the normal clock of the Observatory before and after every complete observation.

The very serious matter of the instability of the azimuthal position of the axis of the Transit instrument was met by erecting marks east and west, distant 400 and 500 feet respectively from collimating objectives. By means of these marks the azimuth could be tested as often as required. It was found that the axis was liable to occasional disturbances in azimuth to the extent of $2''$ of arc in as many hours. A careful discussion of all the readings of the marks showed a small but discernible systematic movement, sufficient to introduce errors into the observed declinations. The marks were observed before and after every complete observation, and any observed change of azimuth was assumed to have taken place uniformly with the time during the interval.

Another point—apparently insignificant, but in reality of the utmost importance—was the illumination of the field. This was effected by an annular metallic elliptic reflector, placed in the central cube at an angle of 45° to the optic axis. The inclination of the reflector was slightly altered from its former position. Formerly the illumination of the field was obtained from a lamp suspended to the wall of the observing room, which was only effective when the telescope was in the vertical position. The illumination was now made so as to be independent of the position of the tube. This change would have no effect upon the deduced zenith distances so long as the illumination was precisely similar (*égal*) in the two positions of the horizontal axis; but it is otherwise if the field is illuminated in the two positions by reflection from different parts of the ring. All possible care was taken to neutralise this troublesome source of error.

Twenty-four stars were selected for observation, well placed in Declination (that is, culminating very close to, and north of, the zenith of the instrument), and pretty evenly distributed in the 24 hours of Right Ascension, so as to insure observations at all seasons of the year. The series commenced 1879 December 17 and terminated 1882 January 29, during which interval 566 complete observations were obtained. The period embraces two *maxima* and two *minima* * of aberration of each star; but it hap-

* The *minimum* means the *negative maximum*.

pened that some of the winter stars were observed at only one *maximum* and one *minimum*.

All the observed declinations were reduced to the mean epoch 1881·0 by the *Tabulæ Pulcovenses*. The proper motions in declination for some stars were taken from Auwers' Fundamental Catalogue, or from Becker's Catalogue of 521 Bradley's stars. For the other stars, M. Nyrén himself deduced the proper motions from the best available data.

In the Equations of Condition the annual parallax of the star is introduced as one of the unknown quantities to be determined; but as the observations were made near the epochs of *maximum* aberration—and consequently when the coefficient of parallax was almost insensible—the introduction of the parallactic term was merely to obtain its effect upon the inferred Constant of Aberration.

Each complete observation furnishes an Equation of the form

$$ax + by + cz + n = 0,$$

where $a = -1$, $b =$ the coefficient of aberration, $c =$ the coefficient of parallax, $n =$ observed mean declination − tabular, $x =$ the correction to the adopted mean declination, $y =$ the correction required to the aberration 20″·445, $z =$ the parallax of the star.

M. Nyrén then gives, for each observation, the observed declination, and the values of n, b, and c.

The following table exhibits the mean result obtained from each star.

	R.A.	No. of Observations.		
	h m			
β Cassiopeiæ ...	0 3	26	$y = +$ ″·045 + ·88z	± ″·067
δ Cassiopeiæ ...	1 18	44	+ ·081 + ·46	·039
χ Cassiopeiæ ...	1 26	22	+ ·224 + ·73	·054
2 H. Camel. ...	3 19	23	+ ·078 + ·49	·053
10 H. Camel. ...	3 55	11	+ ·181 + ·60	·085
B. D. 793 ...	4 13	21	+ ·041 + ·47	·062
11 Camel. ...	4 56	23	− ·148 + ·27	·058
37 Camel. ...	5 59	17	− ·018 + ·29	·095
2 Lyncis	6 9	24	− ·066 − ·11	·062
14 Lyncis ...	6 43	25	− ·004 + ·18	·059
15 Lyncis ...	6 47	30	− ·288 − ·06	·059
24 Lyncis ...	7 33	33	− ·138 − ·14	·060
υ Urs. Maj. ...	9 43	31	+ ·059 + ·04	·044
74 Urs. Maj. ...	12 24	18	+ ·072 − ·37	·050
75 Urs. Maj. ...	12 25	11	+ ·052 − ·38	·040
Radcliffe 3104 ...	13 46	10	− ·052 − ·51	·052
ι Draconis ...	15 22	41	+ ·218 + ·38	·023

	R.A. h m	No. of Observations.	
θ Draconis ...	16 0	35	$y = +\cdot177 + \cdot28z \pm \cdot021$
b Draconis ...	18 22	38	$+\cdot186 + \cdot08$ $\cdot023$
o Draconis ...	18 49	41	$+\cdot071 + \cdot05$ $\cdot024$
Rad. 4511 ...	19 51	15	$+\cdot042 + \cdot54$ $\cdot080$
Rad. 5074 ...	20 56	10	$+\cdot103 + \cdot84$ $\cdot098$
B.A.C. 7387 ...	21 10	11	$+\cdot016 + \cdot76$ $\cdot112$
15 Cephei ...	22 0	6	$+\cdot318 + \cdot65$ $\cdot145$

Ten observations only were rejected, the observed Declinations being more than $0''\cdot6$ in error.

Weighting these in accordance with their probable errors, the mean is obtained,

$$y = +0''\cdot105 + 0\cdot19\pi \pm 0''\cdot0086,$$

where π is the mean parallax of the observed stars.

The author considers that this method of weighting the separate determinations would be proper if the observations, or rather the coefficient of aberration, were uniformly distributed in Right Ascension; but as this was not strictly the case, he divides the equations into four groups for each six hours of R.A., and thus obtains the following mean values:—

R.A.	h h 0 to 6,	$y = +0''\cdot066 + 0\cdot52\pi \pm 0''\cdot026$
	6 to 12,	$y = -0\cdot067 - 0\cdot02\pi \pm 9\cdot040$
	12 to 18,	$y = +0\cdot163 + 0\cdot16\pi \pm 0\cdot025$
	18 to 24,	$y = +0\cdot127 + 0\cdot13\pi \pm 0\cdot019$

Here the probable errors are inferred from the differences between these mean corrections and the separate corrections of the preceding table, taking into account the weights of the latter.

The author remarks, "The high degree of accuracy obtained in the individual observations justified the expectation that the groups thus formed would have been in better agreement. In fact the greatest discordance is between the two intermediate groups in which the individual observations have the smallest probable errors. It is therefore highly probable that the results are not free from systematic error." This inference is shown to be more probable by arranging the observations in monthly means in the order of time; it is then seen that from February to August 1881 the signs of the mean corrections are all *negative*.

M. Nyrén is not able to suggest any cause for systematic error other than temporary changes of personal equation of the observer, variations of latitude of the instrument, or lateral

refraction, each of which would be likely to produce accidental rather than systematic errors.

The author finally adopts the arithmetic mean of the four groups, viz. :—

$$y = +0''{\cdot}072 + 0{\cdot}20\pi \pm 0''{\cdot}014,$$

and considers that the degree of uncertainty of this result is pretty accurately indicated by the probable error assigned—a conclusion in which few will be inclined to agree with him in the face of the above discrepancies of the R.A. groups.

The mean parallax of the stars (π) is, of course, unknown; but, considering that the stars that contributed the largest parallax factors were of less than the fifth magnitude, it cannot be doubted that π is extremely small.

The other series of observations from which this Constant has been inferred were also made at Pulkowa, by M. Wagner, with the large meridian Transit instrument, on the Right Ascensions of three circumpolar stars, in the years 1861–72, which are as yet only in part published. The accuracy of these observations surpass anything of the kind previously obtained.

The stars observed were α and δ *Ursæ Minoris*, and *Cephei* 51 (Hevelius). With few exceptions all the meridian passages were observed both by eye and ear and by the chronographic method. The Constant of Aberration has been inferred separately from the two series.

The observations, which were exceedingly numerous, were combined in groups of a fortnight each. After attributing to each transit a weight depending on the quality of the images and number of wires observed, Equations of Condition were formed precisely similar to the preceding [x, of course, now being the correction required to the adopted Mean Right Ascension], from which M. Nyrén obtains the following results :—

	No. of Culminations.*	
α Ursæ Minoris, E. & E.	232, 207	$y = +0''{\cdot}033 \pm 0''{\cdot}005$
		$z = +0{\cdot}016 \pm 0{\cdot}005$
Chronog.	218, 211	$y = +0{\cdot}044 \pm 0{\cdot}004$
		$z = +0{\cdot}005 \pm 0{\cdot}005$
δ Ursæ Minoris, E. & E.	136, 144	$y = +0{\cdot}028 \pm 0{\cdot}023$
		$z = +0{\cdot}029 \pm 0{\cdot}011$
Chronog.	133, 143	$y = +0{\cdot}021 \pm 0{\cdot}022$
		$z = +0{\cdot}042 \pm 0{\cdot}012$
Cephei 51 (Hev.) E. & E.	123, 101	$y = +0{\cdot}068 \pm 0{\cdot}020$
		$z = +0{\cdot}032 \pm 0{\cdot}011$
Chronog.	125, 110	$y = +0{\cdot}001 \pm 0{\cdot}019$
		$z = +0{\cdot}029 \pm 0{\cdot}011$

* The two numbers given in this column are the numbers of Upper and Lower Culminations respectively.

Adopted Mean Correction of the Aberration Constant 20″·445 } +0″·038 ± 0″·003.

This probable error does not represent the degree of accuracy of the result, as is shown by taking account in the equations of nutation, proper motion, and possible instrumental variations.

We have, therefore, two new and entirely independent determinations of this Constant, viz. :—

20″·517 from the Prime Vertical observations of Declination ;

20·483 from the Meridional observations of R.A.

M. Nyrén then gives the following summary of the various determinations that appear to him entitled to a high degree of confidence—all obtained at Pulkowa, but with three different instruments.

(*a.*) Vertical Circle. Observations of *α Ursæ Minoris* in declination.

Series by M. Peters	20″·507 ± 0″·021
„ Gyldén	20·469 ± 0·026
„ Nyrén	*20·498 ± 0·021
Mean for the Vertical Circle ...	20·495 ± 0·013

(*b.*) Meridional Transit. *α Ursæ Minoris.*

MM. Schweizer–Lindhagen	20″·498 ± 0″·012
M. Wagner	20·483 ± 0·012
Mean for Meridional Transit ...	20·491 ± 0·009

(*c.*) Prime Vertical Transit.

Series by W. Struve	20″·463 ± 0″·017
„ M. Nyrén	20·517 ± 0·014
Mean for Prime Vertical	20·490 ± 0·011

With equal weights, the mean of these is the definite result for the Constant of Aberration,

20″·492 ± 0″·006.

As recently suggested by Mr. A. M. W. Downing,† this value will probably be accepted by astronomers as hardly admitting of improvement from observations made in the Northern Hemisphere. G. L. T.

* Misprinted in the Memoir 20·495.

† *Observatory*, 1883, December.

Mr. G. W. Hill's Paper on the Lunar Theory.

Mr. G. W. Hill has contributed to the *American Journal of Mathematics* an able paper, entitled, "On certain possible Abbreviations in the Computation of the Long-Period of the Moon's Motion due to the direct Action of the Planets."

It is well known that the calculation of the coefficients of these important inequalities has been hitherto regarded as extremely difficult. The author shows how, by the use of his method, this calculation can be greatly facilitated. The work may be divided into two portions, independent of each other. In one, the object is to develop, in periodic series, certain functions of the Moon's coordinates, which in number do not exceed five. This portion is the same whatever planet is considered to act, and hence may be done once for all.

In the other portion we have to find the coefficients of certain periodic terms in the development of certain functions, five also in number, which involve the coordinates of the Earth and planet only. And this part of the work is very similar to that in which the perturbations of the Earth by the planet in question are the things sought. As the multiples of the mean motions of these two bodies, which enter into the expression of the argument of the inequalities under consideration, are necessarily large, approximate values of the coefficients may be obtained by means of semi-convergent series.

The author's method of finding these coefficients is based on that given by Cauchy in Tome xx. of the *Comptes Rendus*, but he introduces a modification of the method, founded on a very elegant solution of a set of simultaneous equations, by means of which a great saving of labour is effected.

Auwers' Mittlere Oerter von 83 Südlichen Sternen.

This important paper is a continuation of the same author's larger work, entitled *Fundamental-Catalog für die Zonenbeobachtungen am Nordlichen Himmel*, published in 1879 as No. XIV. of the series *Publicationen der Astronomischen Gesellschaft*, and forms No. XVII. of the same series. The *Fundamental-Catalog* extended to $-10°$ Dec., and this addendum is intended to supply zero points for the zone observations of stars situated between $-10°$ and $-32°$ Dec.; of the new stars seventy-nine being between these limits of declination, and the remaining four lying between the Equator and $-10°$ Dec.*

The authorities for the star places, in addition to those used

* This catalogue of 83 Southern stars was first published in the *Vierteljahrsschrift der Astron. Gesellschaft*, 1880, p. 280, but without any details.

for the *Fundamental-Catalog*, are the Cape Catalogue for 1860, the Williamstown Catalogue for the same epoch, the First Melbourne General Catalogue for 1870, Safford's Right Ascensions of 505 stars from the Cambridge (U.S.) Observations 1862–1865, the Washington Catalogue for 1860, and the Washington Transit-Circle Observations 1872 to 1875. And Dr. Auwers' general method of proceeding has been to find the corrections applicable to the Greenwich Nine-Year Catalogue, the Washington Catalogue (1860), the Cape, Melbourne, Williamstown, and Cambridge (U.S.) Catalogues, to reduce them to the system formed from a combination of the Greenwich First and Second Seven-Year Catalogues. Through the medium of this latter system the above-mentioned Catalogues are referred to the Pulkowa Catalogue for 1865 (which has been adopted as the fundamental system for the zone observations), and the other Catalogues which have been used in the investigation are also referred to the same system by the application of the requisite corrections. The adopted mean place for 1875·0 of each star is then deduced by taking the mean according to weight of its place found from each Catalogue used, the Catalogue place having been reduced to the fundamental system. The greatest normal weight (7) is given to Pulkowa 1865, the next highest (4) to Pulkowa 1845 and Greenwich 1872, and smaller weights to the other Catalogues.

On looking over the interesting Tables for reduction of the different Catalogues to the fundamental system, on p. 27 of this memoir, it is somewhat remarkable that the great majority of the Catalogues require corrections *of the same sign* to reduce them to the Pulkowa system for 1865. This is noticeable all through the range of declination for the R.A.'s, and for the declinations it is very striking for stars south of the Equator. With regard to the R.A.'s, it may perhaps be pointed out that Nyrén has found (*Das Æquinoctium für* 1865·0, p. 31) that the difference of Equinox for Pulkowa (1861–1870) *minus* Greenwich (1836–1870) is as much as $+0^s.064$. Further, it is to be remarked that the geographical position of Pulkowa is somewhat unfavourable for determination of the Equinox, owing to the low altitude of the Sun when culminating south of the Equator. Dr. Auwers himself recognises the probability of error in the declinations of the Pulkowa system for stars south of the Equator, which will perhaps be more clearly seen by comparing this system with Auwers' Mean System of Declinations (*Ast. Nach.* No. 1536), or with the system deduced by Boss (cf. *Observatory*, vol. iii. p. 479).

Although, therefore, astronomers will probably differ in opinion as to the accuracy of the fundamental system adopted for reduction of the zone observations of the *Astronomische Gesellschaft*, there can be no doubt but that Dr. Auwers has done much to secure the success of this great undertaking by the care and skill which he has bestowed on the formation of these fundamental Catalogues, without which it would be impossible to bring the work to a satisfactory termination. A. W. M. D.

The Moon's Semi-diameter.

Prof. H. M. Paul, formerly assistant at the United States Naval Observatory, and late Professor of Astronomy at the University of Tokio, has published in an Appendix to the *Washington Observations for* 1879, a determination of the Moon's semi-diameter from two occultations of the *Pleiades*.

The two sets of occultations occurred in 1877 and 1879, and were observed with the 9·6-inch Equatorial, employing a power of 132 for most of the stars. All the immersions in both sets were at the bright limb of the Moon, and all the emersions at the dark limb.

For the 1877 observations the atmosphere was unsteady, the stars and the limb of the Moon being blurred and trembling. They were made at zenith distances of 71° to 53° and the immersions were very unsatisfactorily observed, Prof. Paul remarking that "he did not observe what he could be sure was an actual occultation of a single one of the seven stars at the bright limb, but he struck the observing key when the star seemed to lose itself in the light of the Moon." The emersions were more satisfactory.

The observations of 1879 were made when the atmosphere was extraordinarily steady, so much so that the author states that the condition of the images as regards steadiness and excellence of definition was such as he had never seen before at that place.

Prof. Paul's object was to deduce from the observations a correction to the ephemeris semi-diameter of the Moon, and also, as a necessary accompaniment, corrections to its Right Ascension, Declination, and Horizontal Parallax.

The relative positions adopted for the stars were those as determined by Wolf's differential measures applied to Newcomb's position of η *Tauri*, the proper motions depending upon a comparison of Wolf with Bessel, and the common proper motion of the group assigned by Newcomb.

Each set of occultations is discussed separately, and a table is given in which the residuals are arranged according to the grouping of the points of occultation round the Moon's limb, also with reference to bright and dark limb, and also with reference to the relative magnitudes of the stars.

In the discussion of the results of 1877, Prof. Paul calls attention to a curious relation between the residuals and the relative magnitudes of the stars. There is shown to be a difference of about $1''{\cdot}4$ in the resulting values of the semi-diameter if the stars are divided into two groups: one, those brighter than the mean magnitude, the other, those fainter, the *brighter* giving the *smaller* value of the semi-diameter. He concludes that the resulting corrections from the 1877 occultations cannot be

considered as of much value on account of the probability of constant errors of larger magnitude than the resulting probable errors would indicate.

The 1879 observations give far more satisfactory results. They show that Wolf's positions of the stars are probably the best available at present.

The observations also show that the general figure of the Moon's limb must be almost a perfect circle. The deduced correction to Hansen's value of the mean semi-diameter is,

$$-1''{\cdot}69 \pm 0''{\cdot}12,$$

and the resulting value of the mean semi-diameter of the Moon as given by the fourteen occultations of 1879 is,

$$15'\ 31''{\cdot}78 \pm 0''{\cdot}12.$$

Prof. Paul next considers Airy's determination of the occultation semi-diameter from the discussion of 296 scattered occultations observed at Cambridge and Greenwich between the years 1830 and 1860. These give the following results, with the probable errors derived by Prof. Paul from further consideration of Airy's paper:—

From 132 Immersions at Dark Limb	15′ 32″·68	± 0″·16
64 Emersions at Dark Limb	15 32·28	0·24
51 Immersions at Bright Limb	15 34·08	0·29
49 Emersions at Bright Limb	15 36·19	0·31

Comparing these results with his own, he concludes that it is impossible to determine the position of the Moon's centre by meridian or altazimuth observations with any such degree of accuracy as that of a star, and that such determinations of the Moon's position are not of much value for the accurate determination of the Moon's occultation semi-diameter by means of scattered occultations. Prof. Paul considers the value that he has obtained as the most reliable thus far determined.

In conclusion, he suggests that the only way to observe occultations at the bright limb of the Moon, so as actually to *observe the real occultation*, is to use such a high magnifying power as to make a decided difference in colour between the star and the Moon's limb; and for a more accurate determination of the figure of the Moon's limb, he proposes heliometer measures of the diameter in the direction of the line of cusps near the time of Full Moon, when the position-angle of this line is changing very rapidly; but the mountain ranges on the limb, which would have a varying height according to the libration, would probably render such measurements uncertain.

The careful manner in which Prof. Paul has discussed his observations renders his paper a valuable contribution to the

subject, and his result for the mean semi-diameter of the Moon will probably be received by astronomers with confidence.

E. B. K.

Dr. Meyer's Observations of Saturn.

Some interesting researches on the Planet *Saturn* have been undertaken at the Geneva Observatory by Dr. W. Meyer.

In 1880 and 1881 the dimensions of the planet were micrometrically measured with the 10-inch Refractor, and the results for 1881 have been published in the *Astronomische Nachrichten*, No. 2517. The dimensions were measured on twenty-two evenings in such a manner that every dimension is the result of an independent series of observations. An attempt was made to determine the question of the excentric position of the ball within the rings, but without result.

The following are the resulting dimensions of *Saturn* for the mean distance 9·5389.

	1880.	1881.	Diff.	±	No. of Obs.
	″	″	″	″	
Exterior diameter of the bright ring	40·43	40·35	−0·08	0·038	22
Diameter of the ring in the middle of Cassini's division		34·48		0·098	4
Interior diameter of the bright ring	26·30	26·05	−0·25	0·059	21
„ „ dusky ring	21·15	21·13	−0·02	0·085	5
Distance between the extremity of the ring and the planet on the west	11·59	11·34	−0·25	0·026	20
Ditto on the east	11·41	11·30	−0·11	0·038	20
Equatorial diameter	17·40	17·77	+0·37	0·028	21
Polar diameter	16·18	16·12	−0·06	0·055	20
Compression	$\frac{1}{14·5}$	$\frac{1}{10·7}$			

These measures may, in some respects, be compared with some more recent observations on *Saturn's* rings made by Prof. Otto Struve, published in the *Astronomische Nachrichten*, No. 2498. The observations were made in the year 1882 with the 14-inch Refractor of the Pulkowa Observatory, reduced to the mean distance 9·5389, and corrected for phase. Employing the usual designations A, B, and C for the outer and inner bright rings and the dusky ring.

Distance from Limb of Planet.

	Preceding Ansa.	Following Ansa.	Diff.
	″	″	″
Inner boundary of C	1·44	1·53	+0·09
Inner boundary of B	3·72	3·61	−0·11
Outer boundary of B	8·27	8·13	−0·14
Outer boundary of A	11·20	11·20	0·00

Professor Struve compares the mean of these measurements with the series he made in 1851 with the following satisfactory result:

Distance from Limb of Planet.

	1851.	1882.	Diff. 1882–1851.
Inner boundary of C	1″·61	1″·49	−0″·12
Inner boundary of B	3·64	3·66	+0·02
Outer boundary of B	8·24	8·20	−0·04
Outer boundary of A	11·03	11·20	+0·17

Dr. Meyer's observations put into the same form, and compared with Prof. Struve's, are—

Distance from Limb of Planet.

	Meyer (1881).	Struve. (1882).	M−S
Inner boundary of C	1·68	1·49	+0·19
Inner boundary of B	4·14	3·66	+0·48
Outer boundary of B	8·36	8·20	+0·16
Outer boundary of A	11·29	11·20	+0·09

Dr. Meyer remarks that the interior diameter of the bright ring (B) could not be measured with very great accuracy, since the interior edge of the ring did not appear sharply bounded.

Considering that Dr. Meyer's observations were measures of the diameters of the rings, and Prof. Struve's distances were from the limb of the planet to the edge of each ring, the agreement is satisfactory.

In 1882 it was pointed out by Prof. Schiaparelli that Encke's fine division in the outer ring was not symmetrical on the two sides. On 1881 November 15 he noted that the line was well seen in the following ansa, and divided the outer ring almost exactly in half. On the preceding ansa the division was seen with difficulty, but it was not in the middle of the ring, but nearer the outer limb, and divided the entire breadth into two parts, of which one was twice the width of the other. Dr. Meyer has confirmed Prof. Schiaparelli's observation in every particular. Further observations at Milan, in January and February 1883, confirm those made in 1881. This very strange feature does not appear to have been observed except at Geneva and Milan.

Dr. Meyer has published in the *Astronomische Nachrichten*, No. 2527, a very interesting investigation of the commensurabilities of the revolution periods of the satellites of *Saturn* with the periods which satellites would have if revolving at the distances of certain divisions in the ring; and he finds that,

including Cassini's division, there are seven places where the satellites would unite to exercise a perturbing influence on the members of the ring system. If the fact of Encke's division being excentric to the other divisions in the ring be established, the problem will be very much complicated.

Continuing his researches, Dr. Meyer has given in the *Astronomische Nachrichten*, No. 2528, a new determination of the orbits of all the satellites except *Mimas* and *Hyperion;* the former he was able to observe five times, and the latter not at all. The following are the mean distances and periods, which are closely accordant with received values :—

	Mean Distance.	Period.
	"	d h m s
Enceladus	34·3501	1 8 53 6·92
Tethys	42·7514	1 21 18 25·62
Dione	54·7574	2 17 41 9·29
Rhea	76·4838	4 12 25 11·57
Titan	176·9102	15 22 41 23·16
Iapetus	514·7108	79 7 49 24·84

Dr. Meyer has also calculated the mass of *Saturn* from each one of the satellites, making due allowance for the influence of the Sun, the rings, and the polar flattening of *Saturn*, with the following results :—

	Mass.	Weight.
Enceladus	0·000284213	1·0
Tethys	0·000288215	4·4
Dione	0·000288531	9·1
Rhea	0·000288898	15·5
Titan	0·00028704	73·1
Iapetus	0·000285849	48·6

The mean mass which results according to the above weights is

$$\text{Mass} = \frac{1}{3482{\cdot}9 \pm 5{\cdot}5}.$$

This value agrees almost exactly with that recently obtained* by Prof. Asaph Hall from observations of *Iapetus* $= \frac{1}{3482{\cdot}2}$, and differs very little from Jacob's determination of the mass from elongations of *Titan* $= \frac{1}{3487{\cdot}2}$.

E. B. K.

* *Monthly Notices*, vol. xliv., p. 7.

Schiaparelli's Observations of Mars.

During the last ten or twelve years the physical features of the planet *Mars* have received a large amount of attention from observers. The combination of the drawings of Mr. Dawes by Mr. Proctor, so as to form a chart of the whole surface of the planet, the features of which were named on the hypothetical view that the dark markings were seas and the light spaces land, was of undoubted value as affording a fairly reliable and ready means of identifying any particular feature. In 1875 Dr. Terby, of Louvain, published his comparative examination of all the physical observations made of *Mars* from the time of Fontana, in 1636, to the year 1873, which he entitled *Aréographie*. In this important memoir he discussed and correlated all available drawings by reference to Mr. Proctor's chart, and thus made an important advance in our knowledge of the true features of the planet. Several series of drawings of considerable value have been made at recent oppositions—notably the exquisite Madeira series of Mr. Green; and two or three charts of the planet have been published, which represent the physical features with perhaps more detail than was possible from the series of drawings Mr. Proctor used.

At the very favourable opposition of 1877, Prof. G. V. Schiaparelli devoted a considerable amount of attention to the planet, the results of which he published in Series 3, vol. ii. *Atti della Reale Accad. dei Lincei*, entitled, "Osservazioni astronomiche e fisiche sull' asse di rotazione e sulla topografia del pianeta *Marte*." Not only was the position of the planet's axis determined, the areographic places of sixty-two fundamental points fixed, upon which a chart prepared from a long series of drawings could be reliably laid down, but a very elaborate and detailed description was given of every portion of the surface visible at that opposition. The memoir was accompanied by only four drawings, enough, however, to show a very close agreement with other drawings of similar phases. The map, given only in outline, however, showed many new features in the form of fine lines, presenting the appearance of a sort of network arrangement. These canals appear to be confirmed in many respects by careful comparison with other drawings, wherein some of them appear either as fine lines, or as the boundary lines of different tints or shadings.

At the opposition of 1879, Prof. Schiaparelli continued his researches on the planet with the same exhaustive care and attention which he had devoted in 1877. The results, contained in vol. v. of the same *Transactions*, form one of the most important works yet published on the subject. The position of the axis of rotation was determined from eighty-nine measurements of the

south polar spot, and by combining the results of this series with those obtained in 1877 the coordinates of the projection of *Mars'* north pole on the celestial sphere were found to be

R.A. = 318° 7'·8, Decl. = + 53° 37'·1, Epoch 1880·01.

In the two oppositions of 1877 and 1879, 482 observations were obtained, which fix the areographical places of 114 fundamental points. Upon these observations a new chart was constructed, which, unlike that published in the first memoir, showed the relative intensity of the markings.

This memoir is accompanied by too few copies of the original drawings, for, as the map shows an increase in the number of the fine lines which formed so conspicuous a feature in the earlier chart, and which observers have found so difficult to identify, it is the more necessary for that purpose to possess copies of as many of the original drawings as possible for comparison with others. And the importance of this is now conspicuous, for from his observations of *Mars* at the opposition of 1882, Prof. Schiaparelli has constructed a new chart, which presents some most novel features. "The 'canals' of 1877 and 1879 are scarcely recognisable, but their place is more than supplied by a great number of narrow straight lines, distributed for the most part in pairs of parallel lines, distant from each other from 5° to 10° of a Martial great circle, and intersecting the equatorial regions in every direction. These lines are perfectly hard and distinct, each is perfectly uniform in breadth and intensity from end to end, and the majority are represented as being as distinct and dark as are the large markings that are shown on all the best drawings of the planet." There appears to be as yet no confirmation of the duplication of the "canals" thus indicated. But leaving the 1882 observations to be confirmed or not in the future, the high value of Prof. Schiaparelli's researches on the planet cannot be underrated. The determination of the position of so many well-recognised points on the surface of *Mars* by micrometric measurement forms the foundation of a far more accurate chart than was previously possible. It is very probable that some of the disputed canals have been represented too strongly, and that they are only discernible with an exceptionally clear atmosphere. Mr. Burton's observations of *Mars* in 1879 have confirmed some of them. A drawing of the "Terby Sea" by Dr. Lohse, recently published in vol. iii. of the *Potsdam Observations*, represents it as a square, three angles of which correspond with the points of junction of three canals shown in the Milan drawing; and it is probable that many other new features discovered by Prof. Schiaparelli will be thus confirmed.

With regard to the nomenclature adopted in maps of *Mars*, it is most desirable that there should be some agreement established among astronomers on the question. The principle

adopted by Mr. Proctor, of designating the "lands and seas" by the names of astronomers, was provisionally a convenient one, and this was continued by Mr. Green and M. Flammarion in their maps, but with modifications. Prof. Schiaparelli has adopted the divisions of land and water, but selected his names from ancient geography and history, and the confusion in the nomenclature thus introduced renders the discussion of any particular region of the planet rather difficult. It is desirable that these different systems should not continue, and that some agreed nomenclature should be generally adopted. E. B. K.

Dr. Huggins' Method of Photographing the Solar Corona without an Eclipse.

In our last Report we mentioned the experiments of Dr. Huggins with this object in view, and also his results up to that time, which seemed to show that he had succeeded in getting an impression of the Corona upon his plates.

During the past year he has continued his work on the Sun with a more suitable form of apparatus (which will be found described in the Report of his Observatory), and has obtained photographs on a larger scale, and in several respects freer from the presence of possible sources of instrumental error. The original negatives were placed in the hands of Mr. Lawrance and Mr. Woods (the photographers who went to Caroline Island), to be compared by them with the photographs taking during the eclipse of May 6. Bad weather in this country prevented any photographs being taken here on that day.

Mr. Lawrance reports "the outline and distribution of light in the inner Corona of April 3 is very similar to that on our plate which had the shortest exposure; the outer Corona is, I think, hidden by atmospheric glare. As a result of the comparison, I should say that Dr. Huggins' Coronas are certainly genuine as far as 8′ from the limb."

Careful examination of three of the negatives taken on April 3, May 31, and June 6 show a large rift near the north pole similar to the rift which is so conspicuous a feature in the eclipse photographs.

A committee has been appointed by the Royal Society for the purpose of taking photographs of the Sun by Dr. Huggins' method, at some place of high elevation. If photographs can be taken under these circumstances to show the Coronal details with sufficient distinctness, it is scarcely possible to overvalue their importance with reference to the advance of our knowledge of that which exists immediately about the Sun.

The Potsdam Physical Observatory.

The third volume of the publications of this Observatory has recently appeared, and it contains some interesting researches.

Dr. Oswald Lohse has continued his physical observations of *Jupiter* and *Mars;* those of *Jupiter*, ranging from 1878 to 1881, are accompanied by several drawings. The Red Spot was carefully observed, and a series of micrometric measurements were made of its distance from the limb.

An important series of photographs of *Jupiter* were taken with the 11-inch Refractor, and Dr. Lohse succeeded in photographing the Red Spot, two Equatorial Belts, and the North Polar Zone. The photographs appear to have been so successful that the ellipticity of the planet could be fairly determined by measurements of the photographic image.

A short series of observations of *Mars* in 1879 is accompanied by a few very carefully executed drawings.

The second paper in this volume is an investigation of the mass of *Jupiter*, by Dr. P. Kempf. He has employed for this purpose the observations of differences of R.A. of *Jupiter* and Satellites III. and IV., made by Vogel in 1868 to 1870, and some observations of Satellite IV. made by Airy in 1832 to 1836, which he has reduced anew. Comparing the different values of the mass of *Jupiter*, obtained from observations of the satellites and from perturbations, the averages of which are

From observations of the satellites ...	$\mu = 1047{\cdot}817$
From perturbations	$\mu = 1047{\cdot}583$

Dr. Kempf adopts the mean of these as a final result,

$$\mu = 1047{\cdot}700.$$

In the third paper Dr. Vogel and Dr. Müller have published an extensive series of spectroscopic observations of 4051 stars, down to the 7·5 magnitude, in the zone $-1°$ to $+20°$ Declination, the character of the spectra being briefly indicated.

Dr. Gustav Müller has published in this volume an important photometric investigation of the extinction of light by our atmosphere. The observations were confined to comparisons of five stars—*α Aurigæ*, *α Cygni*, *η Ursæ Majoris*, *δ Persei*, and *α Tauri*, at different altitudes with *Polaris*. A Zöllner photometer was employed throughout. For zenith distances greater than 80° *Polaris* was not used, but planets were observed when rising and setting, and the extinction was deduced from the differences between consecutive readings of the intensity circle. The final result arrived at is that the zenithal brightness of a star is 0·8250 of its light before incidence, or in other words, the atmosphere absorbs $\frac{7}{40}$ of the original light. This result is in very satisfactory accordance with the researches of Bouguer,

Seidel, and lately by Prof. Pritchard, as may be seen by the following comparison :—

Ratio of the zenithal light of a star after absorption to the light before incidence :—

Bouguer	0·8123
Seidel	0·8039
„ (second determination) ...	0·7942
Pritchard (Oxford observations) ...	0·791
„ (Cairo „) ...	0·843
Müller	0·8250

Finally, the author concludes from the discussion of the observations, that Lambert's extinction theory is sufficient to satisfy the results, so long as no greater accuracy than 0·09 to 0·10 of magnitude is desired.

Longitude Determinations.

The United States Hydrographic Office has published an important series of Telegraphic Determinations of Longitudes in Japan, China, and the East Indies. The longitudes of very nearly all the prominent positions in the East Indian Archipelago, on the shores of the China and Japan Seas, and the Western Pacific Ocean, have been referred to one of the following points, viz.: Singapore, Batavia, Manilla, Hong Kong, Shanghai, Nagasaki, and Yokohama; and were the longitudes of these initial points known exactly, further work would be unnecessary. But the longitudes of these Secondary Meridians, which have been accepted for the last forty years, have depended mostly upon observations of Moon culminations, and liable to an uncertainty of from one to four minutes of arc.

The expedition sent out by the United States was under the command of Lieutenant-Commander Green, U.S.N., who is well known in connection with longitude work. The object was to form a chain of longitudes through Yokohama, Nagasaki, Wladiwostok, Shanghai, Amoy, Hong Kong, Manilla, Cape St. James, Singapore, Batavia, connected with Madras.

The work was carried out in its entirety, and the following important corrections to be applied to the Secondary Meridians adopted by the British Hydrographic Office, were made :—

Place.	Correction.
Batavia (Observatory)	+30″
Singapore (Fort Fullerton)	− 3
Manilla (Cathedral)	− 5
Hong Kong (Cathedral)	− 6·5
Shanghai (British Consulate Flagstaff) ...	+29
Nagasaki (Minage Point)	0·0
Yokohama (Hospital Square)	+30·5

The last volume of the *Monthly Notices*, contains two interesting papers on longitude determinations in South Africa. The first, by Dr. Gill, being a preliminary account of a Telegraphic Determination of the Longitude of the Royal Observatory, Cape of Good Hope. The paper contains an account of the operations for connecting the longitudes of Aden and the Cape, which were successfully carried out; and though the definitive results are not yet published, the determination is one of very great importance.

A series of secondary longitudes on the east coast of Africa, determined by Mr. Finlay while engaged in the larger work connecting the Cape with Aden, forms the other paper in the *Monthly Notices* referred to. Mr. Finlay thus determined the longitudes of Delagoa Bay, Quilimane, Mozambique, and Zanzibar.

The proposed Unification of Longitudes and Time.

At the meeting of the International Geodetic Association at Rome in October last, the question of the adoption of a common initial meridian for reckoning longitudes and time was discussed. Delegates from the following fifteen States took part in the discussion, viz.:—Austria, Bavaria, Belgium, Darmstadt, France, Great Britain, Hamburg, Italy, Norway, Prussia, Roumania, Russia, Spain, Switzerland, and the United States. After receiving the Report of the Permanent Commission, which recommended the adoption of the meridian of Greenwich, the Conference adopted the following resolutions, by 30 votes against 1 abstention:—

"*Résolutions de l'Association Géodésique Internationale concernant l'Unification des Longitudes et des Heures.*

"La septième Conférence générale de l'Association Géodésique internationale réunie à Rome, à laquelle ont pris part des représentants de la Grande-Bretagne, ainsi que les directeurs des principales éphémérides astronomiques et nautiques, et un délégué du Coast and Geodetic Survey des Etats-Unis, après avoir délibéré sur l'unification des longitudes par l'adoption d'un méridien initial unique, et sur l'unification des heures par l'adoption d'une heure universelle, a pris les résolutions suivantes:—

"I. L'unification des longitudes et des heures est désirable autant dans l'intérêt des sciences que dans celui de la navigation, du commerce et des communications internationales; l'utilité scientifique et pratique de cette réforme dépasse de beaucoup les sacrifices en travail et les difficultés d'accommodation qu'elle entraînerait. Elle doit donc être recommandée aux gouvernements de tous les Etats intéressés, pour être organisée et con-

sacrée par une Convention internationale, afin que, désormais, un seul et même système de longitudes soit employé dans tous les instituts et bureaux géodésiques, du moins pour les cartes géographiques et hydrographiques générales, ainsi que dans toutes les éphémérides astronomiques et nautiques, à l'exception des données pour lesquelles il convient de conserver un méridien local, comme pour les éphémérides de passage, ou de celles qu'il faut indiquer en heure locale, comme les établissements de port, etc.

"II. Malgré les grands avantages que l'introduction générale de la division décimale du quart du cercle dans les expressions des coordonnées géographiques et géodésiques, et dans les expressions horaires correspondantes, est destinée à réaliser pour les sciences et pour la pratique, il paraît justifié, par des considérations essentiellement pratiques, d'en faire abstraction dans la grande mesure d'unification proposée dans la première résolution.

"Cependant, pour donner en même temps satisfaction à des considérations scientifiques très-sérieuses, la Conférence recommande, à cette occasion, d'étendre, en multipliant et en perfectionnant les tables nécessaires, l'application de la division décimale du quart de cercle, du moins pour les grandes opérations de calculs numériques, pour lesquelles elle présente des avantages incontestables, même si l'on veut conserver l'ancienne division sexagésimale pour les observations, pour les cartes, la navigation, etc.

"III. La Conférence propose aux Gouvernements de choisir, pour méridien initial, celui de Greenwich, défini par le milieu des piliers de l'instrument méridien de l'observatoire de Greenwich, parce que ce méridien remplit, comme point de départ des longitudes, toutes les conditions voulues par la science, et que, étant déjà actuellement le plus répandu de tous, il offre le plus de chances d'être accepté généralement.

"IV. Il convient de compter les longitudes à partir du méridien de Greenwich dans la seule direction de l'Ouest à l'Est.

"V. La Conférence reconnaît pour certains besoins scientifiques, et pour le service interne des grandes administrations des voies de communications, telles que celles des chemins de fer, lignes de bateaux à vapeur, télégraphes et postes, l'utilité d'adopter une heure universelle, à côté des heures locales ou nationales qui continueront nécessairement à être employées dans la vie civile.

"VI. La Conférence recommande, comme point de départ de l'heure universelle et des dates cosmopolites, le midi moyen de Greenwich, qui coïncide avec l'instant de minuit ou avec le commencement du jour civil sous le méridien situé à 12^h ou à 180° de Greenwich.

"Il convient de compter les heures universelles de 0^h à 24^h.

"VII. Il est désirable que les Etats qui, pour adhérer à l'unification des longitudes et des heures, doivent changer de

méridien, introduisent le nouveau système de longitudes et d'heures le plus tôt possible.

Il importe également que le nouveau système soit introduit sans retard dans l'enseignement.

"VIII. La Conférence espère que, si le monde entier s'accorde sur l'unification des longitudes et des heures, en acceptant le méridien de Greenwich comme point de départ, la Grande-Bretagne trouvera dans ce fait un motif de plus pour faire, de son côté, un nouveau pas en faveur de l'unification des poids et mesures, en adhérant à la Convention du Mètre du 20 mai 1875.

"IX. Ces résolutions seront portées à la connaissance des Gouvernements et recommandées à leur bienveillante considération, en leur exprimant le vœu qu'une Convention internationale, consacrant l'unification des longitudes et des heures, soit conclue le plus tôt possible par les soins d'une Conférence spéciale, telle que le gouvernement des Etats-Unis l'a proposée."

The French delegates, however, whilst accepting the resolutions as a whole, voted against those articles which involve the adoption of the meridian of Greenwich, proposing instead of this meridian one through the island of Ferro, defined as being 18° west of Greenwich. The question was also raised as to whether the reckoning of International time should commence at Greenwich noon (as in astronomical reckoning) or at Greenwich midnight (as in civil reckoning), and it was ultimately decided by a majority of 20 against 8 to recommend the adoption of the former. It is proposed to submit these recommendations of the Geodetic Conference for ratification by a special Congress, which the Government of the United States has invited to meet at Washington on Oct. 1 next.

Meanwhile the first practical step towards the unification of time has been taken by the Railway Companies of the United States and Canada, which have adopted throughout their system of railways, 100,000 miles in length, standard time reckoned from four meridians, respectively 5^h, 6^h, 7^h, and 8^h west of Greenwich, and thus agreeing with Greenwich mean time as to the minutes and seconds. Time signals in accordance with this system were commenced by the Yale College Observatory, on Nov. 18, when the new standard "Eastern time," 5^h west of Greenwich, was substituted for New York City Hall time, which is $3^m\ 58^s{\cdot}4$ fast of "Eastern time."

Harmonic Analysis of Tidal Observations.

At the meeting of the British Association at Southampton in 1882, Prof. Adams and Prof. G. H. Darwin were appointed a committee for the Harmonic Analysis of Tidal Observations. The old method of reducing tidal observations consisted

in grouping the heights of high and low tide according to the times after the Moon's transit at which it is slack water. Observations of maxima are unsatisfactory, both because the determination of the time of maximum is affected with uncertainty, and because sufficient data are not thus afforded for a good determination of the tidal constants. For the harmonic analysis a continuous tidal record is necessary, and the data which are analysed consist of the measured height of water at each mean solar hour, without reference to high water. The problem consists in the expression of the height of water as the sum of a series of harmonic terms, the argument of each term being derived from theoretical considerations. The method was inaugurated by Sir William Thomson about fifteen years ago, and it was carried out by a previous committee of the Association, which presented its last Report in 1876. Since that date the use of the method has received a wide extension through the action of the Indian Government, who have constituted a Tidal Department of the Great Trigonometrical Survey, with an office at Poona. The Department is ably directed by Major A. W. Baird, R.E., and with the co-operation of Mr. Roberts in England, issues yearly tables of tidal predictions for all the principal Indian ports.

The Report of 1876 left the subject avowedly incomplete, and the great mass of tidal results have accordingly been left in a condition which renders them inapplicable for theoretical discussion without a great deal of preliminary arithmetical work. The Report of the committee of 1882, drawn up by Prof. G. H. Darwin, was presented at the late meeting of the Association. It occupies sixty-eight pages, and is intended to serve as a manual for the use of the harmonic method. The theoretical part of the Report contains a development of the equilibrium theory of tides, from which is derived a schedule of astronomical tides for which the analysis is to be carried out. The shallow-water and meteorological tides are also discussed.

In consequence of the variability of the inclination of lunar orbit to the equator the heights of the various purely lunar tides are variable from year to year. Instructions are given in the Report for the reduction of each tide to a mean value, and for the correction of the phase according to the longitude of the Moon's node. It is the absence of these reductions which renders the existing tidal results at present unfit for theoretical discussion.

Prof. Darwin has been in constant communication with the India Office during the past two years, and Major Baird has undertaken the arduous task of reducing all the old results according to the system recommended in the Report.

Until now no instructions existed in print for conducting the laborious arithmetical operations required in the reductions; but this want is made good by the latter part of the Report, which explains the arrangement of the analysis, and gives samples of the blank forms for computation, drawn up by Mr.

Roberts. It is recommended that the old plan of operation shall be followed in the main, but considerable modifications are suggested in the treatment of the tides of long period. The last section contains tables of certain functions of the longitude of the Moon's node which are required for the reduction of the lunar tides to mean values. These tables were computed at Poona under the superintendence of Major Baird. It has not hitherto been possible for anyone, excepting the officials of the Indian Government, to carry out the harmonic treatment of tides, because the forms for computation were only privately printed for the India Office, and were totally inaccessible to the public. Prof. Darwin intends to publish an edition of computation forms. It is probable that, through the exertions of General Strachey, permission will be obtained to have the forms reproduced by photozincography, at the office of the Ordnance Survey. Each set of forms consists of a book of over 100 pages of the size known as demy.

It is to be hoped that some of our English harbour boards, and of our colonies, may thus be induced to pay attention to tidal observation, for we are still very far from possessing adequate knowledge of the tides of the world.

The Figure of the Earth.

Prof. G. H. Darwin has also contributed to the *Proceedings* of the Royal Society a short paper giving a solution of the problem of the figure of the Earth, with a different law of internal density from that adopted by Legendre and Laplace.

He shows that this solution is capable of reconciling the observed value of the Precessional Constant with the observed ellipticity of the surface, equally well with Laplace's solution. Two special cases of the proposed solution correspond with the cases of constant modulus of compressibility, and of modulus varying as the first power of the density. In Laplace's solution the modulus varies as the square of the density.

Papers read before the Society from February 1883 *to February* 1884.

1883.

Mar. 9. Observations of Comet *b* 1882, made with the transit circle of the Royal Observatory, Greenwich. Astronomer Royal.

Observations of the partial solar eclipse 1882, November 10. J. Tebbutt.

Observations of occultations of stars by the Moon, of phenomena of *Jupiter's* satellites, and of the eclipse of the Sun 1882, May 16, made at the Royal Observatory, Greenwich. Astronomer Royal.

Observations of the transit of *Venus* 1882, December 6, made at Cambridge, Mass., U.S.A. E. F. Sawyer.

The proper motions of telescopic stars. Prof. R. Grant.

On the observations of the transit of *Venus* 1882, December 5–6, made at the Lick Observatory, Mount Hamilton, California. Prof. D. P. Todd.

Observations of the transit of *Venus* 1882, December 5–6, made at the Observatory, Kingston, Canada. Prof. J. Williamson.

The variability of β *Cygni* and 63 *Cygni*. Rev. T. E. Espin.

Notes on some of Schjellerup's identifications of Al Sufi's stars. J. E. Gore.

On the account of William Ball's observations of *Saturn* in the *Philosophical Transactions*. H. T. Vivian.

Note on observations of *Mercury*. W. F. Denning.

Observations of occultations of stars by the Moon and of phenomena of *Jupiter's* satellites, made at Stonyhurst in 1882. Rev. S. J. Perry.

Note on Prof. Newcomb's remarks on the Windsor observations of the transit of *Venus* in 1874. J. Tebbutt.

Note on a photograph of the great nebula in *Orion*, and some new stars near θ *Orionis*. A. A. Common.

On the magnifying power of a telescope. J. M. Schaeberle.

Notes upon certain doubtful star-places. Prof. T. H. Safford.

On the relative motion of the components of 6 *p. Eridani*. A. M. W. Downing.

Observations of comet *a* 1883, made with the Sheepshanks equatorial at the Royal Observatory, Greenwich. Astronomer Royal.

On the visibility of the dark side of *Venus*. Prof. C. V. Zenger.

Note, accompanying drawings of the Great Comet (*b*) 1882, made at the Observatory, Arcetri, Florence. W. Tempel.

Notes on the transit of *Venus* 1882, December 6. Rev. F. Howlett.

Physical observations of *Jupiter*. W. F. Denning.

Sur les observations du passage de *Vénus*, 1882, Décembre 6, faites à l'Observatoire, Moncalieri. Padre F. Denza.

April 13. Spectroscopic observations of Comet Swift 1883. Dr. N. de Konkoly.

On the position of λ *Ursæ Minoris*. John Tatlock.

Notes on the Great Comet (*b*) 1882. E. E. Markwick.

Note on some criticisms made by Mr. Stone on the methods available for determining the solar parallax. David Gill.

Note on the nucleus of the Great Comet (*b*) 1882, (extract from a letter to Mr. Knobel). David Gill.

On Mr. Finlay's pre-perihelion observations of the Great Comet (*b*) 1882. David Gill.

On the computation of the eccentric anomaly, equation of the centre, and radius vector of a planet, in terms of the mean anomaly and eccentricity. Dr. J. Morrison.

Note on the eclipse of *Jupiter's* fourth satellite on April 4, 1883. Capt. W. Noble.

Observations made at the United States Naval Observatory, Washington. Prof. A. Hall.

Observations of Comet *a* 1883, made at the Royal Observatory, Greenwich. Astronomer Royal.

May 11. Measures of the companion to *Sirius*. S. W. Burnham.

Observations of the companion of *Sirius*, made at the Dearborn Observatory, Chicago. Prof. G. W. Hough.

Post-perihelion observations of the Great Comet (*b*) 1882. John Tebbutt.

Astrophysical observations made during the year 1882 at the Herény Observatory, Hungary. Eugen von Gothard.

Physical observations of *Jupiter* and *Mars*, made during the year 1882, at the Herény Observatory, Hungary. Alexander von Gothard.

Observations of Comet *c* (Schaeberle), made at the Cambridge Observatory with the Northumberland equatoreal and square bar micrometer. Prof. J. C. Adams.

Observations of Comet *a* 1883 (Brooks–Swift), made at the Cambridge Observatory with the Northumberland equatorial and square bar micrometer. Prof. J. C. Adams.

Note on Dr. Morrison's paper on the computation of the eccentric anomaly, &c. Prof. J. C. Adams.

Observations of Sun-spots from May 1877 to February 1883. E. E. Markwick.

On Hell's alleged falsification of his observations of the transit of *Venus* in 1769. Prof. S. Newcomb.

On the solar motion in space. W. E. Plummer.

An explanation of the principal cause of the large errors at present existing between the positions of the Moon deduced from Hansen's Tables and observation; and the cause of an apparent increase in the secular acceleration in the Moon's mean motion required by the tables, or of an apparent change in the time of the Earth's rotation. E. J. Stone.

Note on photographs of κ *Crucis* and of the nebula in *Orion* (extract from a letter to Mr. Stone). R. L. J. Ellery.

Photometric determination of the brightness of the brighter stars north of the equator. Prof. C. Pritchard.

On the orbit of γ *Coronæ Australis*. A. M. W. Downing.

Note with respect to the shadow of the planet *Jupiter*. A. C. Ranyard.

The nucleus of Comet *b* 1882. A. A. Common.

June 8. The annular solar eclipse of 1836, May 15. Alex. Brown.

Preliminary account of a telegraphic determination of the longitude of the Royal Observatory, Cape of Good Hope. David Gill.

Determinations of longitudes on the east coast of Africa. W. H. Finlay.

Note on the chromosphere. Rev. S. J. Perry.

Phenomena of *Jupiter's* satellites observed at Mr E. Crossley's Observatory, Bermerside, Halifax, during the opposition of 1882–3. J. Gledhill.

Observations of U *Monocerotis*, and LL 14551, with a new photometer. Rev. T. E. Espin.

Observations of occultations of stars by the Moon, and of phenomena of *Jupiter's* satellites, made at the Radcliffe Observatory, Oxford, 1877–78, and 1882–83. E. J. Stone.

Elliptic elements of Comet *b* 1882. John Tatlock.
Ephemeris of the satellite of *Neptune*, 1883–84. A. Marth.
Ephemerides of the satellites of *Saturn*, 1883–84. A Marth.
Ephemeris for physical observations of *Jupiter*, 1883–84. A. Marth.
Postscript to note on M. Loewy's communication referring to an apparatus for the determination of flexures. A. Marth.
Note on Delaunay's expression for the Moon's parallax. Prof. J. C. Adams.

Nov. 9. On the change in the adopted length of the tabular "mean solar day," which takes place with every change in the adopted value of the Sun's mean sidereal motion. E. J. Stone.
Ephemeris for physical observations of *Mars*, 1883–84. A. Marth.
Measures of southern double stars. E. B. Powell.
On humidity as a cause of variation of rate in chronometers. Major-General J. F. Tennant.
Note on the mass of *Saturn*. Prof. A. Hall.
Note on some observations of the transits of *Mercury* and *Venus* made in Australia by Mr. Russell and Mr. Tebbutt. Prof. S. Newcomb.
Observations of the variable star R *Carinæ*, from May 1880 to September 1883. John Tebbutt.
Elliptic elements of Comet 1882 I. (Wells). F. J. Parsons.
Jupiter without visible satellites. Rev. S. J. Johnson.
Disappearance of *Jupiter's* satellites. Wentworth Erck.
Showers of large meteors. W. F. Denning.
On the evidence afforded by the Greenwich Lunar Observations 1862–1881 of a change in the adopted unit of time in 1864. E. J. Stone.
Observations of Comet *b* (Pons-Brooks) made at the Royal Observatory, Greenwich. Astronomer Royal.
Note on the Greenwich mean tabular errors of R.A. of the Sun. Edwin Dunkin.

Dec. 14. Ephemeris for finding the positions of the satellites of *Mars* 1883–84. A Marth.
Ephemeris for finding the positions of the satellites of *Uranus*, 1884. A. Marth.
On the change in the adopted unit of time. Major-General J. F. Tennant.
Rotation period of *Jupiter*. W. F. Denning.

On the supposed unreliability of the Greenwich Observations of the Sun in mean results. E. J. Stone.

On the supposed possible independence of Bessel's and Le Verrier's expressions for the mean longitude of the Sun, subject to the conditions imposed upon them by their use in practical astronomy in the determination of mean solar time. E. J. Stone.

Note on a narrow belt on the planet *Saturn*. A. C. Ranyard.

Note accompanying drawing of the Great Comet (*b*) 1882 (extract from a letter to Mr. Stone). General G. H. Willis.

On the change in the unit of time implied in the substitution of Hansen's for Bessel's expression for the longitude of the mean Sun. Prof. A. Cayley.

Observations of Comet *b* 1883 (Pons-Brooks) made at the Royal Observatory, Greenwich. Astronomer Royal.

On the spectrum of Comet *b* 1883 (Pons-Brooks) observed at the Royal Observatory, Greenwich. Astronomer Royal.

The orbit of the Great Comet (*b*) 1882. Dr. J. Morrison.

Note on the recent twilight glow. W. Mattieu Williams.

Remarks on Mr. Stone's explanation of the large and increasing errors of Hansen's Lunar Tables by means of a supposed change in the unit of mean solar time. Prof. J. C. Adams.

Observations of Pons's Comet made at the United States Naval Observatory with the 9·6-inch equatorial. W. T. Sampson and E. Frisby.

1884. Jan. 11. Observations of Comet III. 1882 (Barnard). W. H. Finlay.

The meteor shower of Pons's Comet. W. F. Denning.

On the latitude of the Observatory, Windsor, New South Wales. John Tebbutt.

Observations of occultations of stars by the Moon and of phenomena of *Jupiter's* satellites made at the Royal Observatory, Greenwich, in the year 1883. Astronomer Royal.

Suggestion for an observing seat for transit instruments. Richard Inwards.

Note giving a numerical illustration of the effects of a percentage change in the Sun's mean motion in longitude. E. J. Stone.

The belts of *Saturn*. Henry Pratt.

Spectroscopic results for the motions of stars in the line of sight obtained at the Royal Observatory, Greenwich, in the year 1883. No. VII. Astronomer Royal.

Heliometer determinations of stellar parallax in the Southern hemisphere. David Gill and W. L. Elkin.

Elements of the orbit of Comet *a* 1883 (Barnard's). Robert Bryant.

List of Public Institutions and of Persons who have contributed to the Library, &c. since the last Anniversary.

Her Majesty's Government.
Her Majesty's Government in Australia.
Her Majesty's Government in India.
The Norwegian Government.
The Lords Commissioners of the Admiralty.
British Association for the Advancement of Science.
British Horological Institute.
Geological Society of London.
Institute of Actuaries.
Institute of Civil Engineers.
Meteorological Office.
Meteorological Society.
Photographic Society of Great Britain.
Physical Society of London.
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Leeds Philosophical and Literary Society.
Liverpool Astronomical Society.
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Oxford, Radcliffe Observatory.
Rugby School Natural History Society.
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Adelaide, Royal Society of South Australia.
Amsterdam, Royal Academy of Sciences.
Baltimore, Johns Hopkins University.
Batavia Magnetical and Meteorological Observatory.

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Berlin, Royal Prussian Geodetic Institute.
Bombay Branch of Royal Asiatic Society.
Bordeaux, Society of Physical and Natural Sciences.
Boston, American Academy of Arts and Sciences.
Brussels, Royal Academy of Sciences.
Brussels, Royal Observatory.
Buda-Pesth, Hungarian Academy of Sciences.
Buenos Ayres, Meteorological Office.
Calcutta, Asiatic Society of Bengal.
Cape Town, South African Philosophical Society.
Chicago, Dearborn Observatory.
Christiania, Norwegian Meteorological Institute.
Coimbra, Observatory of the University.
Copenhagen, Royal Academy of Sciences.
Dijon, Academy of Sciences.
Geneva Observatory.
Geneva, Society of Physics and Natural History.
Genoa, Society of Literature and Science.
Göttingen Observatory.
Göttingen, Royal Society of Sciences.
Haarlem, Musée Teyler.
Halle, Imperial Leopold-Caroline Academy.
Harvard College Astronomical Observatory.
Helsingfors, Finnish Society of Sciences.
Hong Kong Observatory.
Leghorn, Technical and Nautical Institute.
Leiden Observatory.
Leipzig, Astronomische Gesellschaft.
Melbourne Observatory.
Melbourne, Royal Society of Victoria.
Milan, Royal Observatory.
Moncalieri Observatory.
Montpellier, Academy of Sciences and Letters.
Moscow Observatory.
Munich, Royal Bavarian Academy.
Naples, Royal Academy of Sciences.
Natal Observatory.
Neuchatel, Society of Natural Sciences.
Ottawa, Canadian Meteorological Office.
Paris, Academy of Sciences.
Paris, Bureau des Longitudes.
Paris, Dépôt Général de la Marine.
Paris, Ecole Polytechnique.
Paris, International Committee of Weights and Measures.
Paris, Mathematical Society of France.
Paris Observatory.

Paris, Philomathic Society of France.
Philadelphia, American Philosophical Society.
Philadelphia, Franklin Institute.
Potsdam, Astrophysical Observatory.
Prague Observatory.
Pulkowa Observatory.
Rio de Janeiro, Imperial Observatory.
Rome, Central Meteorological Office.
Rome, Italian Meteoric Association.
Rome, Italian Spectroscopic Society.
Rome, Pontifical Academy dei Lincei.
Rome, Royal Academy dei Lincei.
St. Petersburg, Imperial Academy of Sciences.
St. Petersburg, International Polar Commission.
San Fernando Observatory.
Sydney Observatory.
Tacubaya Observatory, Mexico.
Tasmania, Royal Society.
Tiflis, Physical Observatory.
Toronto, Canadian Institute.
Toulouse, Academy of Sciences.
Turin, Italian Meteorological Association.
Turin, Observatory of the Royal University.
Turin, Royal Academy of Sciences.
Vienna, Imperial Academy of Sciences.
Washington, Bureau of Navigation.
Washington, Office of the American Ephemeris.
Washington, Smithsonian Institution.
Washington, United States Chief Signal Office.
Washington, United States Coast and Geodetic Survey.
Washington, United States Naval Observatory.
Yale College Observatory.
Yokohama, Seismological Society of Japan.
Zurich Central Meteorological Institution.
Editors of the American Journal of Science.
Editors of the American Journal of Mathematics.
Editor of the Analyst.
Editor of the Astronomical Register.
Editor of the Astronomische Nachrichten.
Editor of the Athenæum.
Editors of the Bulletin des Sciences Mathématiques, &c.
Editor of the English Mechanic.
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ADDRESS

Delivered by the President on Presenting the Gold Medal of the Society to Mr. Common.

Gentlemen,—

Your Council have awarded the Gold Medal to Mr. A. A. Common for his photographs of celestial bodies.

In this award the Council have been less influenced by originality in the methods adopted than by the great practical success which has attended Mr. Common's efforts in a most important and interesting field of astronomical research.

It appears that in 1874 Mr. Common was in possession of a five-and-a-half-inch Refractor, and was even then engaged in astronomical photography. He soon, however, found it desirable to improve his instrumental means, and provided himself with two disks of glass of seventeen inches diameter, with the intention of grinding his own mirrors, and mounting a Reflector of this size. But, fortunately perhaps for our science, Mr. Common abandoned this idea, and supplied himself with an eighteen-inch mirror by Calver. The mounting for this mirror was designed by himself and executed under his direct personal superintendence, and he was able to commence work with this powerful instrument in 1877. But even this instrument appeared insufficient to meet Mr. Common's requirements, and he soon gave an order to Mr. Calver for a mirror of three feet diameter. The first disk of this size burst into fragments under the tool, but a second disk was successfully worked, and the mirror mounted in July 1879. A description of this instrument is given in the *Memoirs*, vol. xlvi. The mounting, which is quite a departure from the usual forms, shows in every direction great engineering skill, guided by the experience gained in the use of the smaller instruments of the actual requirements for successful astronomical work. The method of relieving the friction of the moving parts of the mounting by floating them in mercury, and the special adjustments for the use of the instrument for photographic purposes, are deserving of attention. This powerful instrument has been used in the observation of the fainter satellites of *Saturn* and of *Mars*, and the discovery of many new faint nebulæ, but has been more especially devoted to photographic work. The first attempt at a photograph of the nebula of *Orion* was made on 1880 Jan. 20. The result was a failure. The stars were seen as

lines, and the nebula proper presented merely a faint stain upon the plate; but such failures only suggested the necessity of improved clock-driving and the use of more sensitive plates. Thus availing himself of every increase of the sensitiveness of the prepared photographic plates and continually improving the control of the driving-clock, Mr. Common was able, on 1881 June 24, to obtain a photograph of the Comet *b*, which is probably the earliest successful photograph of any comet (although a photograph of the comet was obtained on the same night by Dr. Draper); whilst on 1882 March 17, a photograph of the nebula of *Orion* was obtained, which was exhibited at the May meeting of the Society, and excited the admiration of all the astronomers who had an opportunity of inspecting it.

But still the clock-work admitted of some further improvements. It was possible to place a wire to afford a visible point of reference of the fixed direction of the instrument relatively to the stars, and thus to allow of a great extension of the time of exposure of the plates without destroying definition.

These practical improvements rendered it possible to secure the splendid photograph of the nebula which was presented to the Society in March 1883. This photograph was taken on 1883 Jan. 30.

The work has been continued, and to allow for the effects of different exposures and the sensitiveness of the plates to light of different degrees of refrangibility, a long series of experiments have been carried out with exposures increasing from 1^m to 90^m. It appears that even with the very long exposures, more details are brought out by every increase in the length of exposure, and that the extreme limit of useful exposure has not even been reached at $1^h\ 30^m$.

With the comparatively short exposure of thirty-seven minutes, stars such as Lassell's *a* and *b* mentioned in Holden's Monograph of the central parts of the nebula in *Orion* are distinctly shown, as well as some of the faint stars discussed by Mr. Common (*Monthly Notices*, vol. xliii. p. 255); while details of the nebula itself, not represented in the best drawings that have occupied so much time and labour, and which indeed the eye can hardly discern and the hand can never properly represent, are clearly shown in the photographs. The success of these long exposures with this powerful instrument has opened out a new field of research by which the accumulating effect of the light of faint stars, too faint even for observation to the eye, have been registered upon the photographic plate. It is indeed difficult to over-estimate the interest with which the results which Mr. Common may obtain in this direction will be watched by astronomers.

In addition to the work mentioned, Mr. Common has obtained some beautiful photographs of other nebulæ and of the planets *Jupiter* and *Saturn*; and has recently applied himself with success to obtaining photographic star maps to stars of the

eleventh magnitude, a field in which Professor Pickering has already made some progress.

Such, gentlemen, is a bare record of the steps which have led Mr. Common to success, and the justification of the Council in awarding to him the medal of the Society. The lesson taught is not a new one. The records of our Society are rich in the labours of our amateur astronomers. The amateur who can provide himself with sufficient instrumental means for original research need fear no professional rivalry; untrammelled by the necessity of continuing observations whose value largely depends on their continuity, having the power of taking up any subject he pleases, pursuing it so long as he believes in the possibility of success, without fear or responsibility of charges of wasted time and wasted means, he possesses advantages which are priceless in the tentative and experimental stages of any work.

It is in work of this class that the most striking advances in our science must be expected; and such work will most certainly repay, by the gratification of personal success, the efforts of those who devote themselves to original work in our science, and the field of research presented is absolutely boundless.

Mr. Common,

It is with the greatest pleasure that I place in your hands this medal as a recognition on the part of the Royal Astronomical Society of the great value of your contributions to the advancement of our science.

The meeting then proceeded to the election of the Officers and Council for the ensuing year, when the following Fellows were elected :—

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